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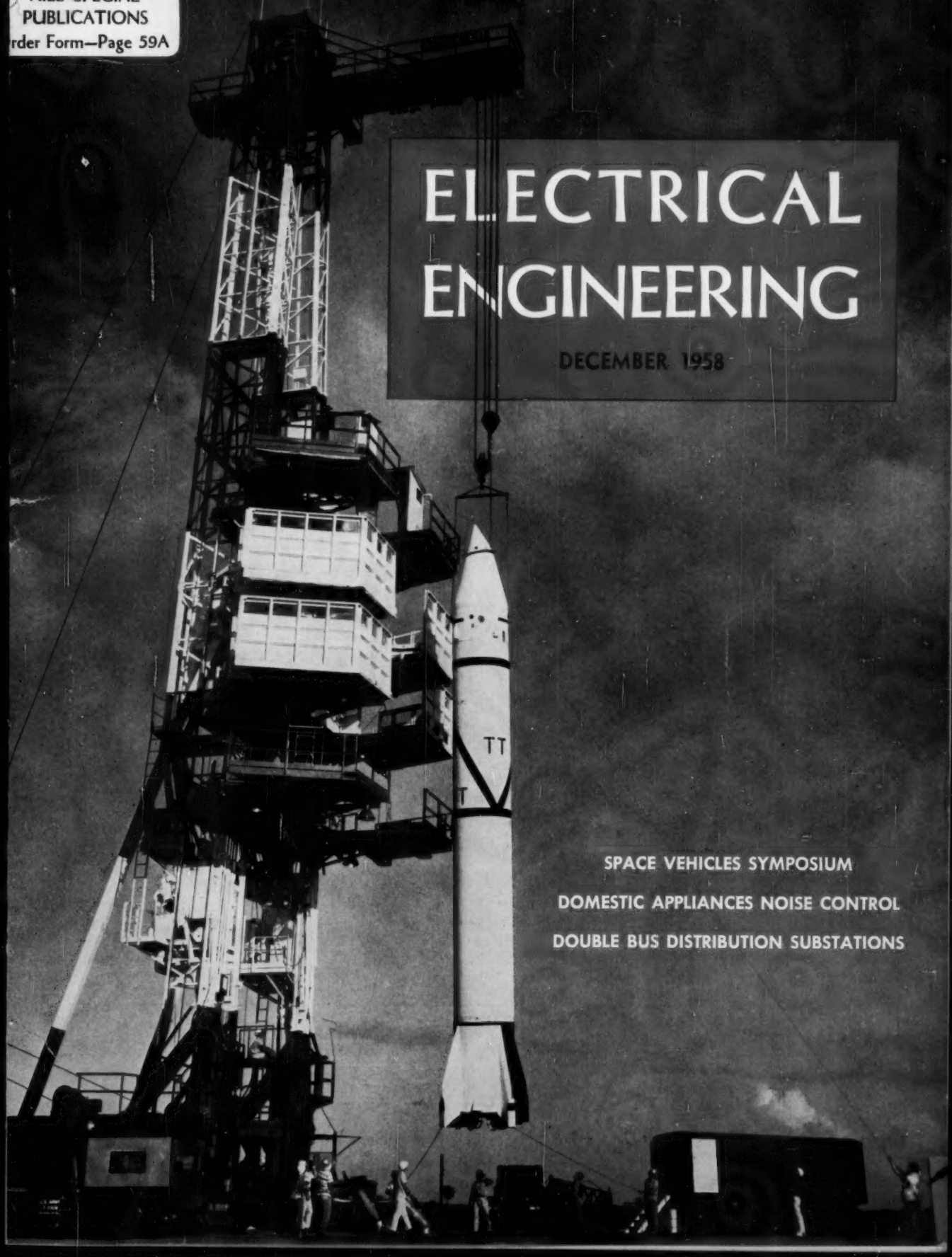
ELECTRICAL ENGINEERING

DECEMBER 1958



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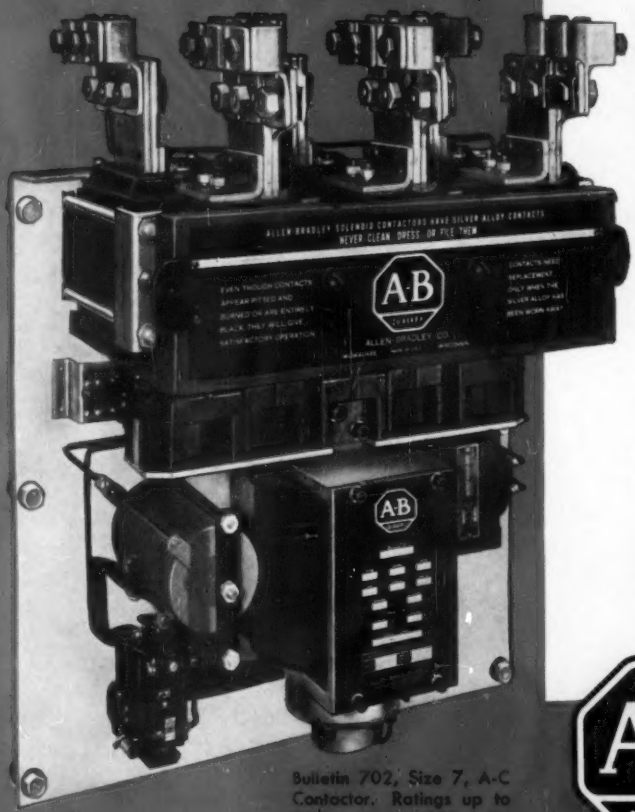
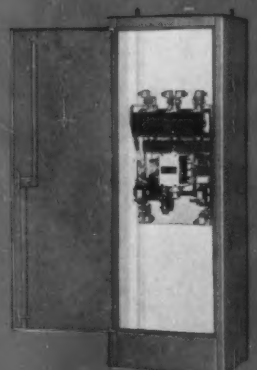
ALLEN-BRADLEY gives you Trouble Free Solenoid Starters in ALL SIZES!

The simple solenoid design—exclusive with Allen-Bradley in the big starter sizes—has only one moving part. This eliminates the trouble causing bearings and flexible jumpers of conventional clapper switches . . . and assures millions of trouble free operations. A-B solenoid starters also have double break, silver alloy contacts that never need any servicing. They are always in perfect operating condition—until the contact is completely used up.

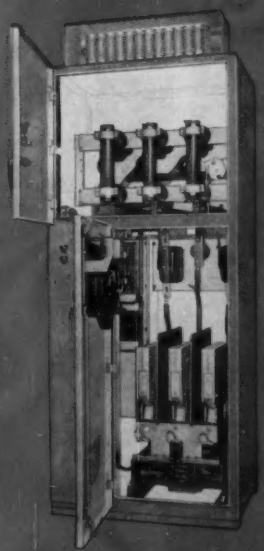
This time-tested solenoid construction is available on *all* Allen-Bradley starters up through Size 7 . . . as well as on A-B's rugged, air break, high voltage starters. Write for full information.



Bulletin 702, Size 7, A-C Contactor. Ratings up to 900 amperes, 600 volts. This basic solenoid contactor is used in large A-B low voltage starters.



Bulletin 709 across-the-line solenoid starters are made in ratings to 300 hp, 220 v; 600 hp, 440-550 v.



A-B high voltage starters are built for all types of motors. Ratings to 1500 hp, 2300 v; 2500 hp, 4600 v.

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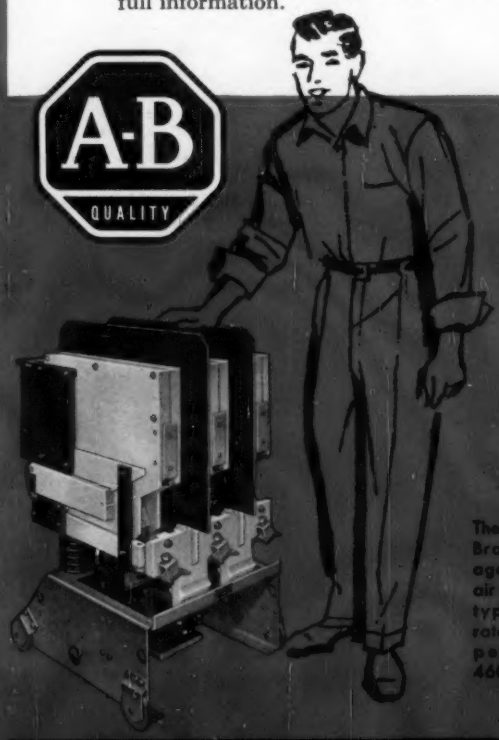

The heart of Allen-Bradley high voltage starters is this air break, solenoid type contactor—rated at 400 amperes, 2300 or 4600 volts.

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ELECTRICAL ENGINEERING

DECEMBER 1958
Vol. 77, No. 12

Published monthly by American Institute of Electrical Engineers

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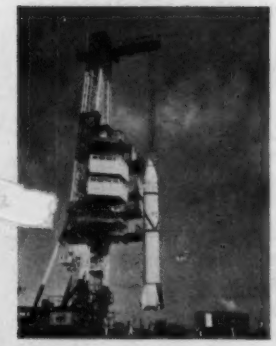

THE COVER: U.S. Army's Jupiter-C missile is gently maneuvered into position within the gantry crane at Cape Canaveral, Fla. The Jupiter-C was used to launch the Explorer IV satellite. The article "Space Vehicles, Satellites, and Missiles—A Symposium" appears on page 1077.

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Statements and opinions given in articles appearing in *ELECTRICAL ENGINEERING* are expressions of contributors, for which the Institute assumes no responsibility. Correspondence is invited on controversial matters. Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
Founded 1884

Headquarters, 10th floor • Editorial Offices, 6th floor
33 West 39th Street, New York 18, N. Y

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ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office Hildreth Press, Bristol, Conn. Editorial and advertising offices 33 West 39th Street, New York 18, N. Y. Member subscription $6 per year nondeductible from dues; single copy 75 cents. Nonmember subscription $12 per year plus extra postage to all countries to which second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Bristol, Conn., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538. P. L. & R. Act of February 28, 1925. December 1958. Vol. 77, No. 12. Number of copies this issue, 61,000.

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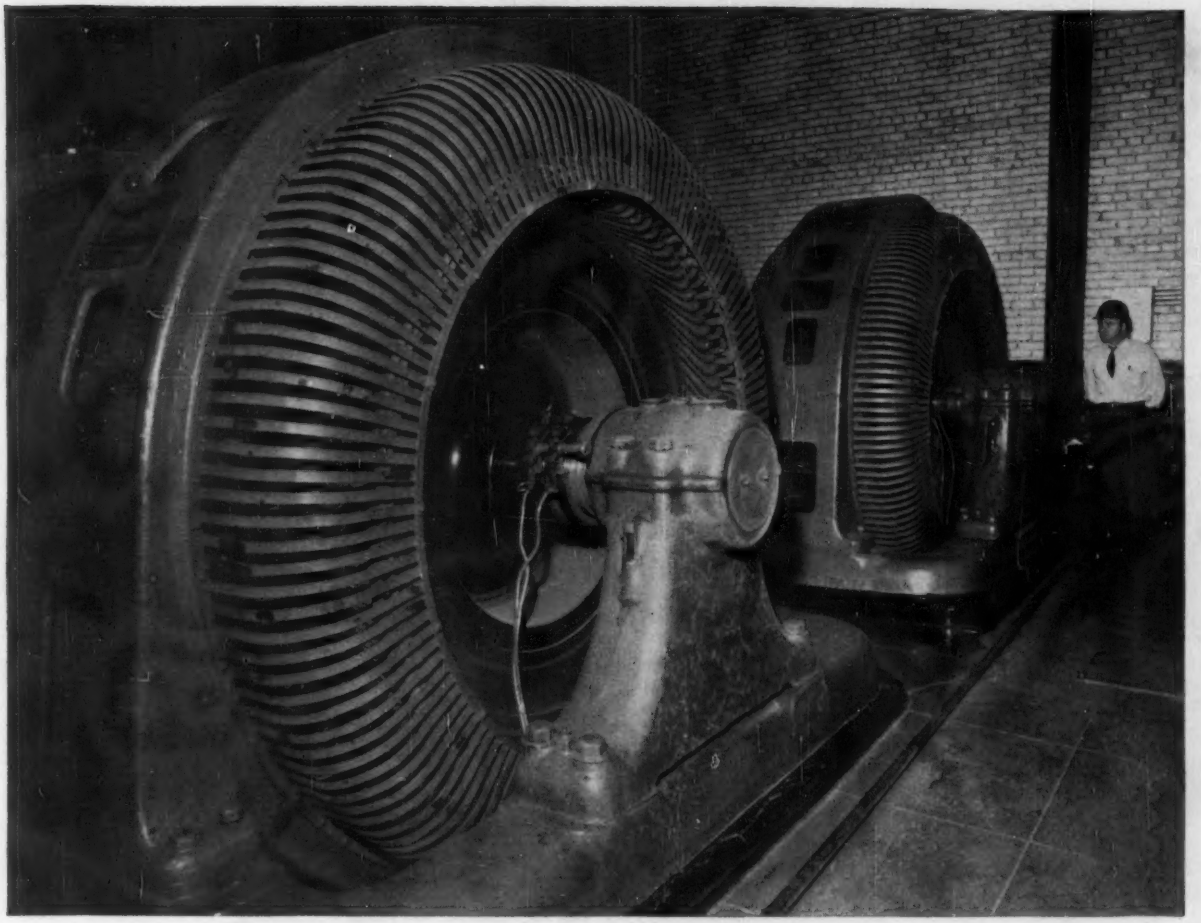

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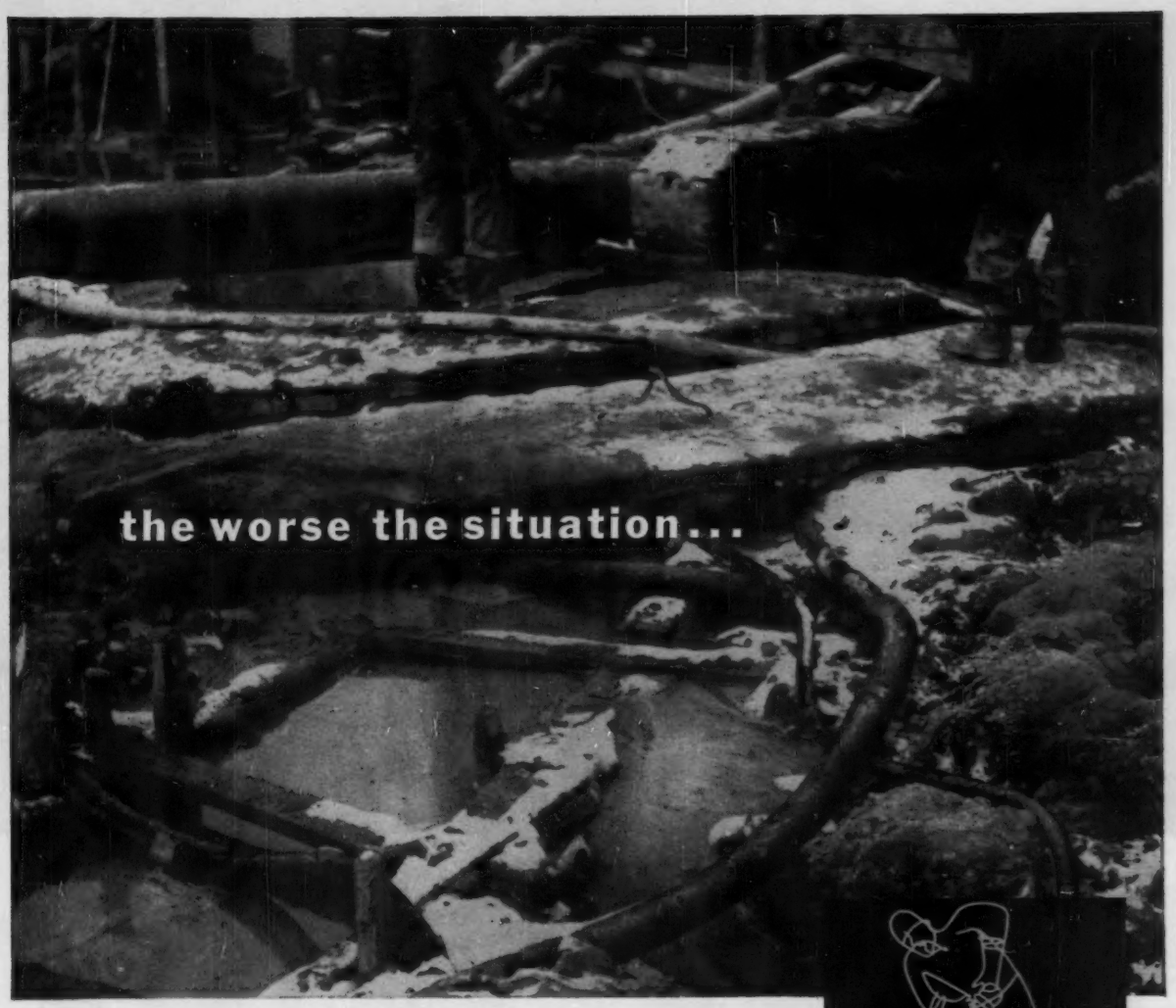

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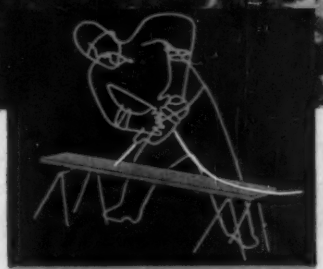

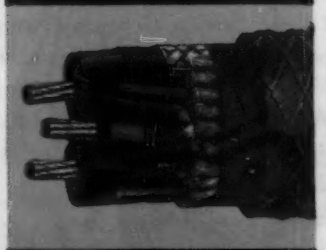

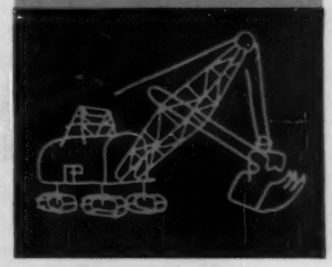

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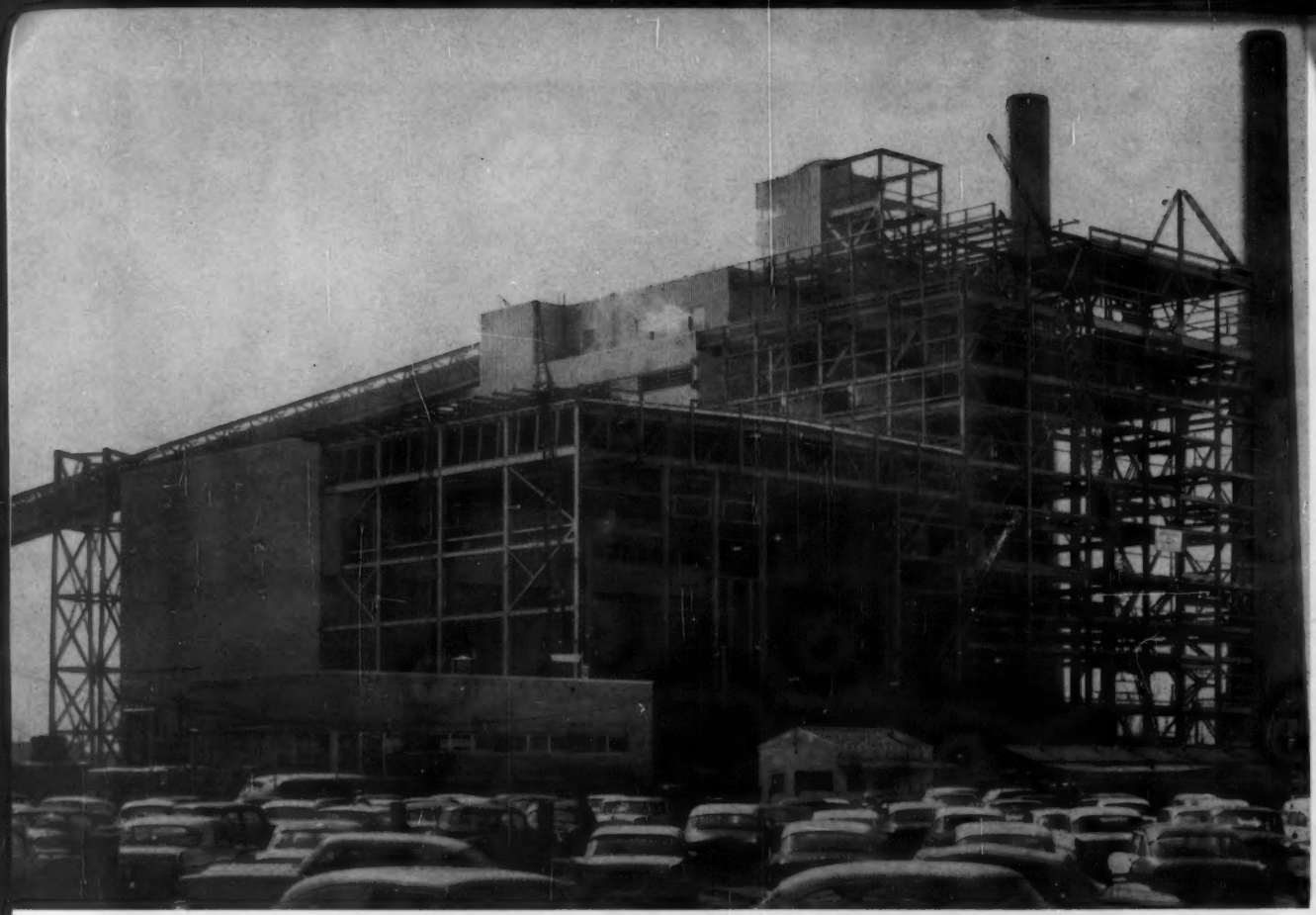

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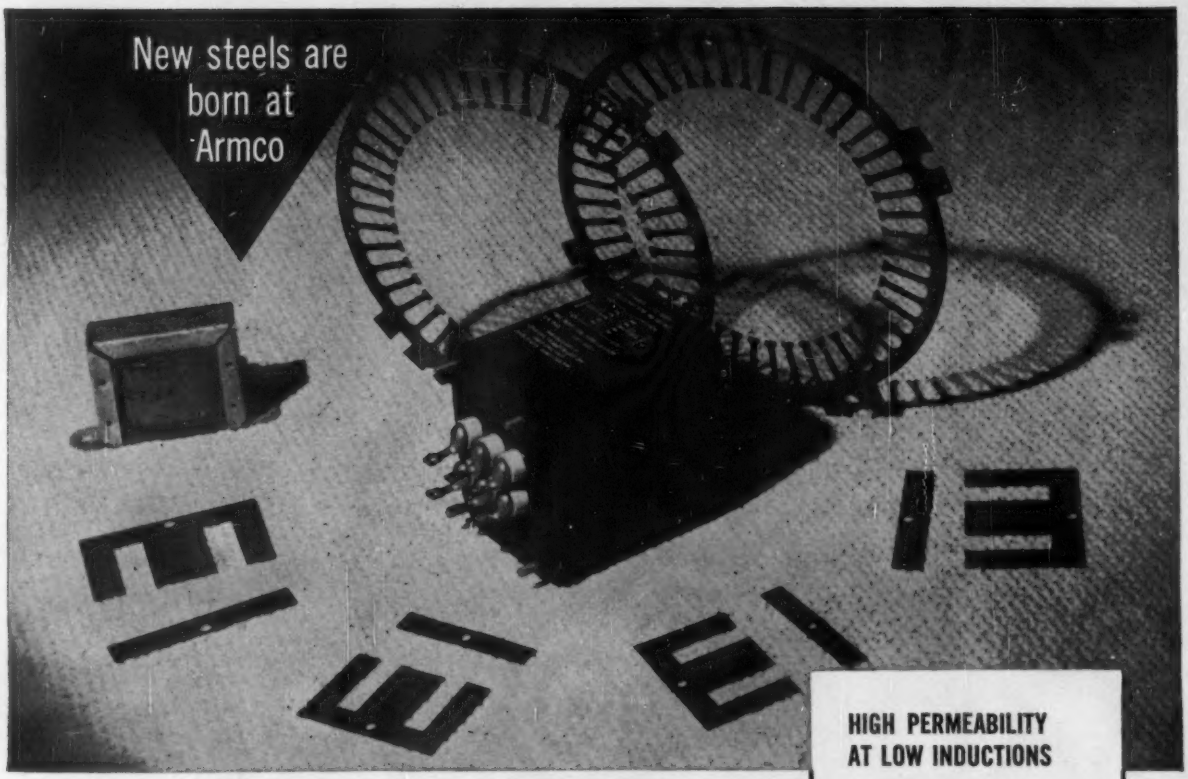

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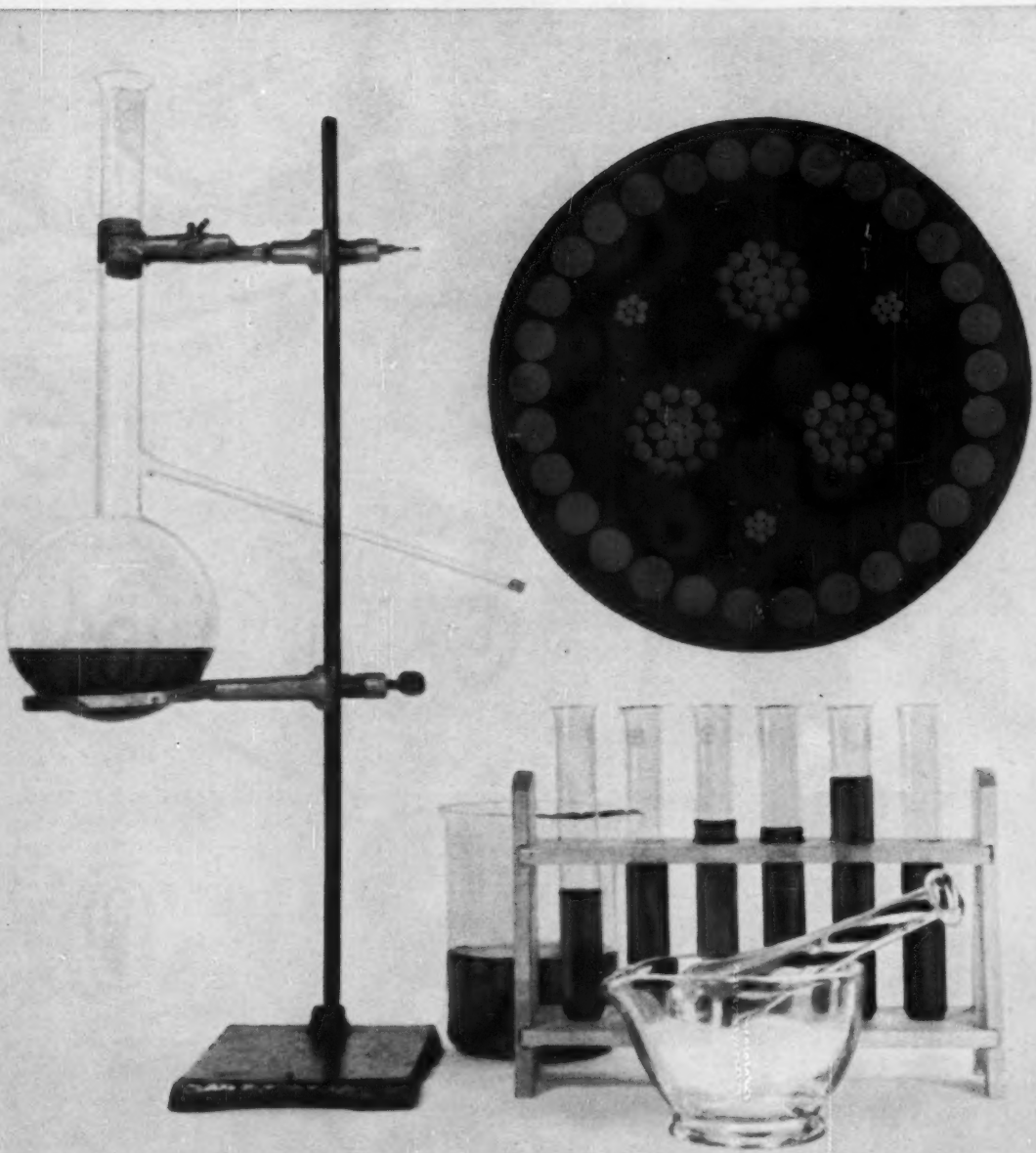

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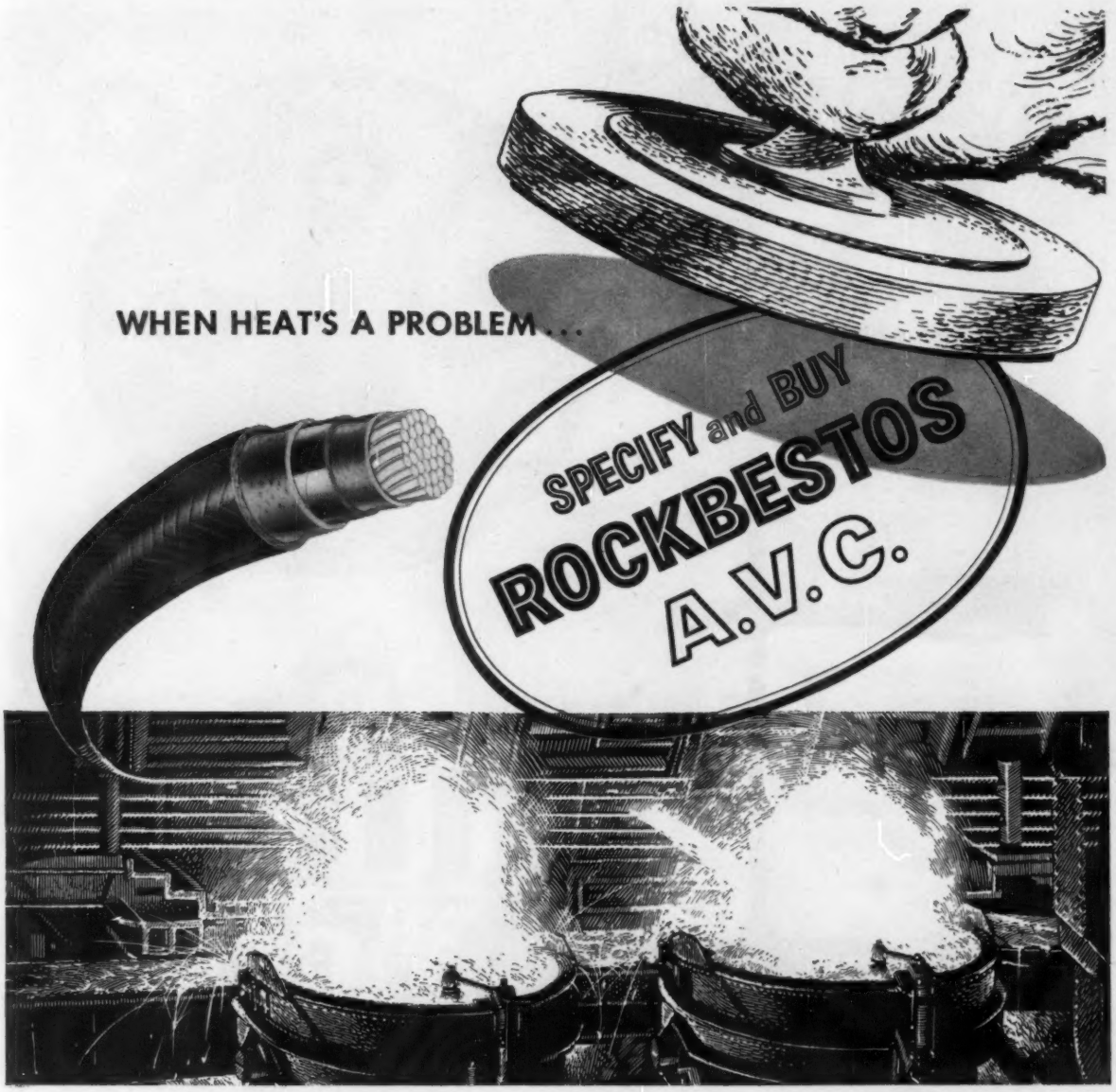

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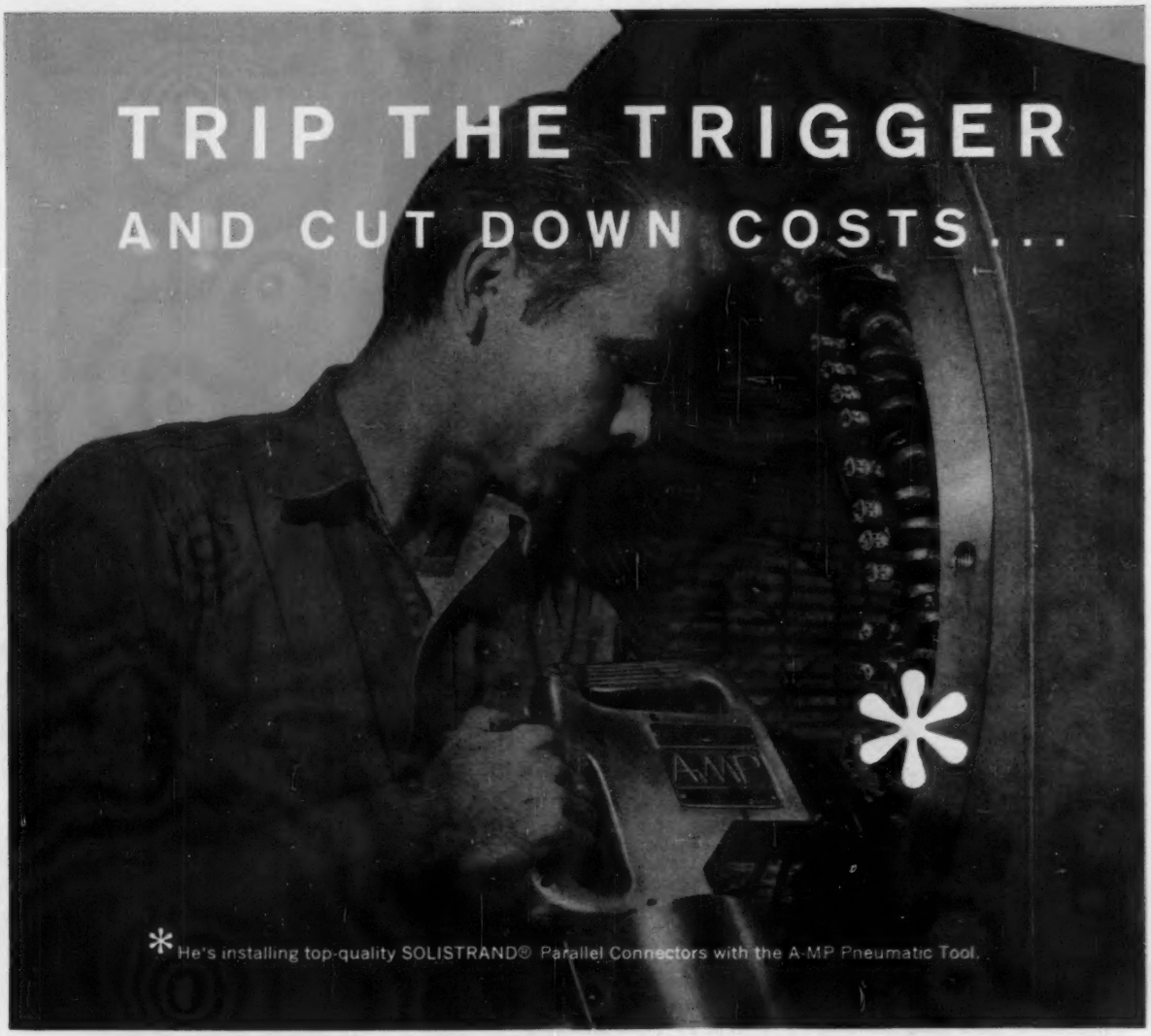
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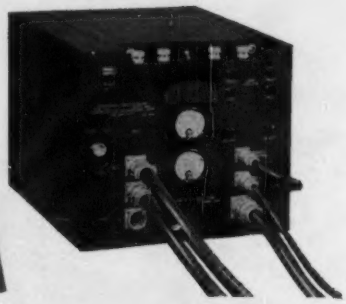

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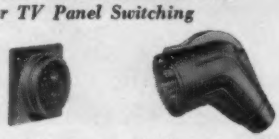

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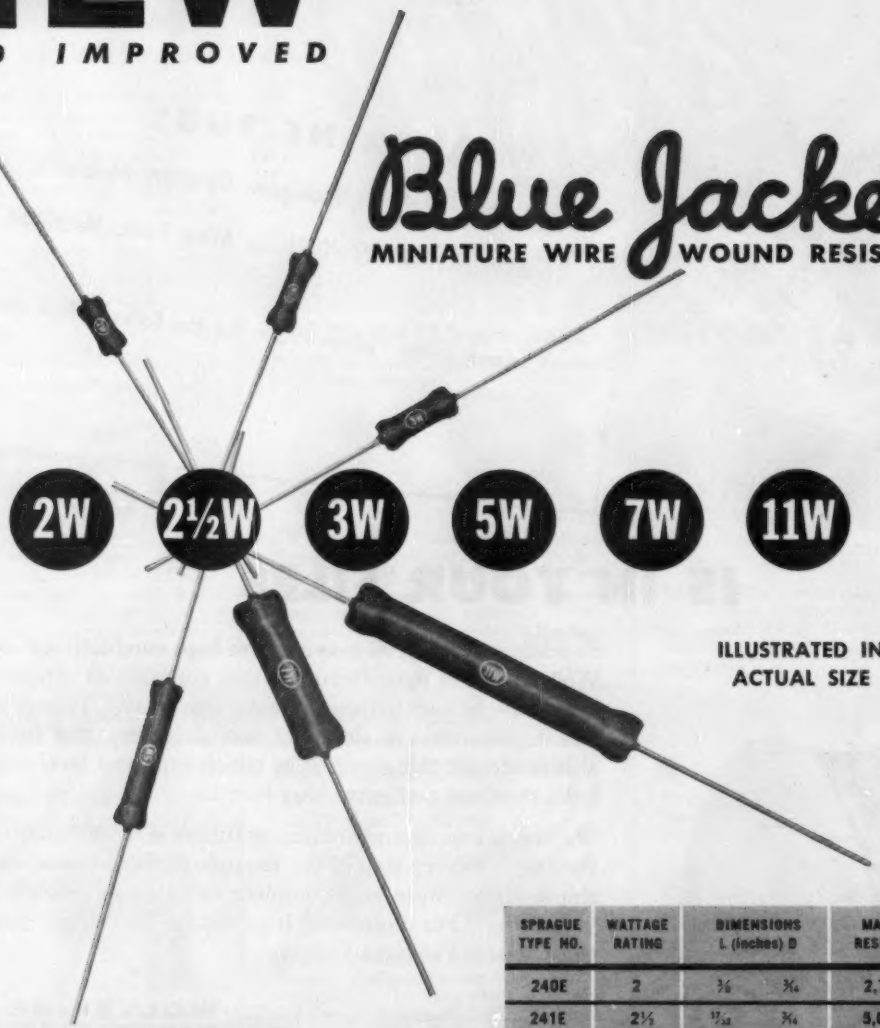

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Space Vehicles, Satellites, and Missiles

A Symposium

A broad discussion by scientific and engineering leaders on the nature of the engineering problems involved in space-flight control. Subject matter comprehends the nature of the underlying space mechanics, the broad characteristics of the associated control and instrumentation problems, system design, and attitude control of satellites and missiles.

Opening Remarks

L. F. HICKERNELL
PRESIDENT AIEE

THOSE OF YOU who know my technical background and experience must wonder at the appearance on the same platform with such a distinguished panel of specialists on this subject. Before I share your astonishment, perhaps an explanation is in order.

In 1940, I was working with Lt. Comdr. Rickover of the Electrical Section, Bureau of Ships, U.S. Navy, on the development of a buoyant cable to be used to explode harmlessly magnetic mines which were wreaking havoc with Great Britain's and our shipping. About a year later, a young naval officer, his single gold stripe still shiney, was assigned to head the mine sweeping equipment group, and co-ordinate the development by the several manufacturers. His name was Ensign D. L. Herr, your moderator for tonight. Thus began a professional and personal acquaintanceship which has continued ever since.

The purpose of this personal reminiscence is to indicate the breadth and range of electrical engineering. In 1941, you might say that Ensign Herr and I met underseas. Tonight, we are privileged to accompany him (now a Lt. Comdr. in the U.S. Naval Reserve) and his eminent specialists into outer space.

In the early days, our British cousins neatly classified electrical engineering into "heavy current" and "light current" engineering, which we Americans characteristically converted to the more practical terms "power" and "communication." Such oversimplification no longer applies, if, indeed, it ever did.

Electrical engineering was born in the physics laboratories. Modern electrical engineering is engaged in the practical use and application of the discoveries made through basic research whether they be in electricity, nuclear energy, or outer space.

Incidentally, you might wonder why a cable engineer would have a technical interest in, say, nuclear energy. Two [illegible] might be cited to illustrate the point.

Our early [illegible] submarine would not operate [illegible] had special insulated cables been designed [illegible] operations encountered in this new service.

Radiation offers the possibility of creating a whole new series of electrical insulating materials suitable, not only for cables but for other applications.

One of the great qualities of a professional society, such as our Institute, is that it brings together men of all specialties in the electrical and allied arts. Thus, it broadens our viewpoint, stimulates our imagination, and cross-fertilizes our ideas. Although each new development creates new specialists, at the same time it brings us closer together because of the interdependence of the several arts and sciences.

Under the program of expanded technical activities instituted in 1947, the AIEE is interested in all new developments from the minute mid nucleus of the atom to the infinite range of space. Accordingly, we are greatly indebted to our Feedback Control Systems Committee, this evening's panel, and its organizing chairman, for arranging this symposium for us tonight. I am looking forward to enjoying the presentations and discussions from the audience.

Introduction

D. L. HERR
MEMBER AIEE

WE ARE ALL highly honored, Mr. Hickernell, to receive the benefit and perspective of your opening remarks, not only as this Institute's President-Elect for 1958-59, but also as a wise and farseeing man devoted to the advancement of our profession and our national technological achievement in these days.

Verbatim report of symposium sponsored by the Feedback Control Systems Committee at the AIEE Summer General Meeting and Air Transport Conference in Buffalo, New York, June 22-27, 1958.

L. [illegible] project engineering, Anaconda Wire and Cable Company, Hastings-on-Hudson, New York, N. Y.

D. L. Herr, AIEE symposium organizing chairman and moderator, with Librascope, Inc., General Precision Equipment Corp., Glendale, Calif.; consulting engineer, Santa Monica, Calif.

Photograph of a portion of the Milky Way from Mount Wilson and Palomar Observatories, courtesy of The American Museum of Natural History, New York, N. Y.

ever-present threat—like those during which we first met professionally and personally 18 years ago. We wish you Godspeed in the work of your presidency which you so richly merit.

Tonight, we are honored further with the distinguished and working panel members gathered here with me. They should be considered representative of that hard core of creative, productive, hard-working group of devoted American scientists and engineers upon whom so much and so many depend today in our country and the world. It was not possible to include all of those men and companies whose efforts and achievements qualify them to appear here, only because of the human time limitations.

Your moderator attempted to achieve some measure of unity in the program arranged for as a whole. Your panel, I am sure, has striven to fulfill this objective. My organizing co-chairman, Prof. George Newton, Jr., associate director of the Massachusetts Institute of Technology (MIT) Servomechanisms Laboratory, and I assume responsibility for any gaps which might naturally appear in this brief, concentrated session.

We begin with Dr. I. M. Levitt, director of the Fels Planetarium of the Franklin Institute, which bears the name of a great patron and friend of science, who was also my patron in my graduate and undergraduate days at the University of Pennsylvania—Samuel S. Fels, whose keen mind and bright eyes would have danced to be with us this evening. And then, we follow immediately with Stark Draper, the dean of our profession of flight instrumentation and control, to whom we citizens and our country deeply owe a great deal for his great contributions in the basic gyroscopic art of the world, which truly places our human co-ordinate reference system in the fixed stars of the Divine Universe.

The Motions of Satellites

I. M. LEVITT

THE MOTIONS OF SATELLITES are well understood in that the basic fundamentals on which the motions are based go back before the invention of the telescope. Today, the scientists can describe the motions of the satellites with great accuracy.

The perturbing influences on the satellite are well understood and can be forecast so that future position can be determined. The precessional effect caused by the equatorial bulge of the earth and the rotation of the line of apsides resulting from the eccentricity of the orbit, the proximity of the satellite, and the intensity of the earth's gravitational field can be computed and the effects considered in an ephemeris.

One other effect of tremendous scientific significance and minute in magnitude is the rotation of the line of apsides caused by the spinning of the earth.

I. M. Levitt is director of The Fels Planetarium of the Franklin Institute, Philadelphia, Pa.

There are three major astronomical consequences of the general theory of relativity. These are the advance in the perihelion of Mercury, the deflection of a ray of light by a gravitational field, and the red shift of the spectral lines because of an intense gravitational field. A fourth consequence has been uncovered and this deals with the additional rotation of the line of apsides because of the spinning of the earth on its axis.

The only planet which would show this shift is Mercury and this only to the extent of 0.01 second of arc per century. This is because the planet is very far from the sun compared with an earth satellite and the rotation of the Sun is so slow. In the case of a satellite, the advance of perigee will be about 50 seconds of arc per century. This value is 5,000 times greater than for Mercury and arises from the close proximity of the satellite and the relatively rapid rotation of the earth.

Man has taken his first step into space. Today, several man-made satellites circle the earth at various altitudes and in unique periods. We can predetermine the height at which we wish to launch a satellite and come pretty close to it. We also try to predetermine the orbit of the satellite and we shall soon be able to accomplish that with considerable accuracy.

There are very definite relationships between altitudes, velocities, and periods of satellites, defined centuries ago by the mathematical geniuses who gave us the laws of celestial mechanics. For example, we know that an orbiting body remains in orbit because the gravitational attraction between it and its central body is exactly balanced by the centrifugal force of its motion in its orbit. The closer a satellite is to the earth, the faster it must move in order to withstand the greater gravitational pull between it and the earth. Our man-made satellites travel at speeds of about 5 miles per second, at distances of only about 4½ thousand miles from the earth's center, while our natural satellite, the moon, travels at only 2/3 of a mile per second at a distance of 1/4 million miles.

The velocity of a satellite can be determined if we equate the gravitational force and the centrifugal force. The former is given by $P_1 = m\ g\ R^2/r^2$; the latter is $P_2 = m\ v^2/r$. Equating them, we have $m\ v^2/r = m\ g\ R^2/r^2$, which reduces to $v^2 = g\ R^2/r$. But r, the distance of the satellite from the center of the earth, is equal to the radius of the earth plus the altitude of the satellite, or $r = h + R$. So we now have $v^2 = g\ R^2/h + R$, and finally $v = \dfrac{\sqrt{g}\ R}{\sqrt{h+R}}$. For brevity, assuming a circular orbit, the circumference is given by $2\ \pi\ (h + R)$ and finally the period is given by the circumference divided by the velocity, or

$$T = \frac{2\ \pi}{\sqrt{g}\ R}\ (h+R)^{3/2}$$

From the moon, almost a full hemisphere of the earth is visible at one time, because it is relatively distant from us. The situation is somewhat different for a nearby man-made satellite which instantaneously can

be seen only from much less than a hemisphere of the earth.

The range of visibility of a satellite, or the area of the earth seen from the satellite (Fig. 1) can also be plotted. This is computed in the following manner:

D = the satellite at distance h above the earth's surface
C = the center of the earth
R = the radius of the earth—3,960 miles
AB = arc of earth's visible surface
Cos $ACD = AC/CD$ but $AC = R$ and $CD = h + R$

$$\text{Cos } ACD = R/h + R$$

By assigning various values to h, we can calculate the corresponding values of the angle ACD.

This latter relationship is, of course, nothing but simple geometry. But the relationship between height of satellite and its period is something that has resulted from the best thinking of some of our greatest minds —not in our time, but centuries ago. Even in Greek days, attempts were made to measure positions of objects in the sky. Such observations improved in accuracy, of course, as time went on, but only slowly. We can say that the birth of celestial mechanics occurred almost at the birth of Tycho Brahe in 1546, only three year after the death of Copernicus.

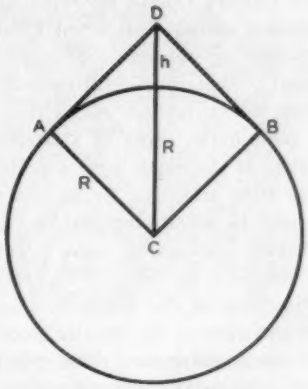
When Tycho was only 14 years old, he was attracted to astronomy by the fulfillment of an eclipse prediction. Little matter that it was wrong by a few hours; it was remarkable to him that such predictions could be made. Later he built, or had built for him, the most precise astronomical instruments of his time. The telescope was not to be invented until almost a decade after Tycho's death, yet the accuracy of his sightings was most remarkable.

Tycho measured the positions of the fixed stars and, most important, he measured continuously, over many years, the positions of the planets as they moved against the background of the stars. It was these latter observations that were destined to play the major role in the development of celestial mechanics.

As a pupil and disciple of Tycho, there came to Prague an ingenious, sensitive young man from Germany. Johann Kepler's mind was literally crawling with ideas, many of them definitely of a mystical or metaphysical nature. He attempted in many ways to explain the relative motions of the planets, fully believing that some harmony could be established, some unifying principles could be stated. The most puzzling planet was Mars, and its motion became Kepler's special project. After the death of Tycho, Kepler inherited all of Tycho's work, but it was the motion of Mars that gave him his clue.

Trying all kinds of combinations of circles and epicycles for the motions of the earth and Mars around the sun, and failing each time, Kepler took the bold step of discarding the ancient idea that the circle was the perfect curve, and chose instead a simple ellipse as the ideal planetary orbit. Then, to his great delight, he

Fig. 1. Area of the Earth seen from a satellite.



could predict with accuracy the future positions of Mars, as well as satisfy the past observations of Tycho. In 1609, the year of the invention of the telescope, he announced his first and second laws of planetary motions and, by 1618, the third of the unifying laws had been established. To arrive at these great generalizations cost him innumerable wrong guesses and years of tedious, incessant calculations.

Kepler's first law is this:	Each planet moves in an ellipse which has the sun in one of its foci.
The second law is this:	The radius vector of a planet passes over equal areas in equal intervals of time.
The third law is this:	The cubes of the mean distances of any two planets from the sun are to each other as the squares of their periods of revolution.

Another effect present in the motions of the planets must manifest itself also in the motion of a satellite. This is the rotation of the orbit in its own plane, a necessary consequence of an elliptical orbit and easily discovered when the orbiting body is relatively close to the primary and the orbit is a considerable departure from a circle.

The planet Mercury offers the best example in the solar system. Its orbit is so eccentric that at perihelion the planet is only 28½ million miles from the sun's center while at aphelion the distance is 50% greater—43½ million miles. The line joining the perihelion and aphelion points—what we call the line of apsides —rotates, in the direction of the planet's motion. We call this the advance of the perihelion. For Mercury, Newtonian gravitational theory predicts an advance of perihelion equal to 531 seconds of arc per century, truly a small quantity, yet observations clearly show that the actual advance of Mercury's perihelion is 574 seconds of arc per century. The excess of 43 seconds

per century cannot be explained by Newtonian gravitational theory. But when Einstein applied his relativity laws of motion to Mercury, the excess was almost exactly explained—42.9 instead of 43 seconds per century, which is close enough!

Now let us think of a satellite revolving around the earth. If the earth were a perfect sphere and the satellite were traveling in an exactly circular path, there would be an almost perfect example of the ideal case of two gravitating mass points: an invariable orbit plane with no advance of perigee, because there is no ellipticity of the orbit. In time, despite the smallness of the mass of the nearby moon and the great distance of the massive sun, these two bodies would affect the orbit, as today they produce the tides on the earth. But even over a considerable period of time, in this ideal case, the perturbations by the moon and sun can be neglected.

But because the earth does have an equatorial bulge other perturbations are introduced. There is an excess gravity caused by the bulge which amounts to about 0.2% of the "spherical" gravity at the surface of the equator. Dr. Opik indicates that this decrease varies as the fourth power of the distance which means that it practically vanishes at great distances. At the poles of the earth, there is a deficiency in mass and the effect is opposite to that in the equatorial plane.

The satellite being a small body of small mass is highly susceptible to an excess or deficiency in gravity. Although the orbit is not distorted, the path which the satellite follows precesses or rotates backwards from East to West about a half-degree per revolution.

This motion may be thought of in terms of the behavior of a hoop. If you take a hoop and sail it down the street, as its forward motion stops the hoop will begin circling round and round until it finally lies flat on the ground. If a thin piece of paper were stretched over the hoop it would describe the motion of the orbit under the precessional influence.

Like Mercury, the satellite is moving in an ellipse around the earth and, as the satellite moves from perigee to apogee, the intensity of the earth's gravitational field changes and, depending on the average distance of the satellite from the earth, the line of apsides of the satellite will rotate.

Thus, the motion of the satellite is a complex one and one under intense investigation today. It is safe to say that for objects so close to the earth scientists have not developed the necessary mathematical tools to deal with resulting perturbations which arise. While we speak of our ability to triangulate over water and determine irregularities in the distribution of surface masses of the earth, until such time as the mathematical tools have been developed to deal with the accuracy of these observations, we will be unable to make fullest use of them.

In 1915, Einstein developed his General Theory of Relativity and it was indicated that astronomical proofs were available to check the theory.

We have already seen that the perihelion of Mercury advances by an excess of about 43 seconds of arc per century. Another consequence is that light is bent by a gravitational field. This is measured only at the time of a total eclipse of the sun when it is possible to photograph distant stars whose light must pass close to the limb of the sun. The gravitational field of the sun will deflect the ray of starlight by about 1.75 seconds of arc at the limb of the sun. This quantity is so small that there is still considerable controversy as to the reality of the measurements made to date. The third effect is the displacement of the spectral lines of a star toward the red. The reasoning behind this is that the gravitational field of the star will alter the frequency of the light emitted by atoms in the sun and stars. Again, this effect is so small that only in the case of the white dwarfs—stars of extraordinarily high density and resultant intense gravitational fields—can this effect be measured.

Thus, the scientist has had a difficult time in trying to verify the general theory of relativity. Now however, another method presents itself in the case of the satellites.

In the classical Newtonian theory of gravitation, the motion of a body around another body—either rotating or nonrotating—is identical. There can be no difference. However, in the general theory of relativity, the speed of the rotation of the central body will definitely affect the behavior of the satellite.

To understand this, let us consider a charged sphere. If we have a stationary charged sphere, it will create an electric field only. If the charged sphere is rotating, it will also create a magnetic field. At the same time, there will act on the moving charge, in addition to the electrostatic field, another force which is proportional to the ratio of rate of motion of charge to the velocity of light. This force is proportional to the magnitude of the charge on which it acts and to the intensity of the magnetic field.

Precisely the same type of additional force (analogous to the magnetic force) acts on the satellite as a result of the rotation of the earth. This additional displacement of perigee can amount to 50 seconds of arc per century. In the case of Mercury this effect amounts to about 0.01 second of arc per century. This is, of course, impossible to observe.

The reason for the smallness of displacement is the slow rotation of the sun—once in about 25 days—and the relatively great distance of Mercury from the sun.

In the case of a close satellite, the advance of perigee resulting from this effect alone will be 5,000 times greater than the displacement of Mercury's perihelion, caused by the same effect. The reason for this is the rapid rotation of the earth and the nearness of the satellite.

There is however, one disturbing element in this search. If the satellite is too close to the earth, it will be slowed by the atmospheric drag and, thus, will make the effect extremely difficult, if not impossible, to detect. If the satellite is too far from the earth the effect will diminish with distance. For this reason, the satel-

lite will have to be as close as possible without permitting other influences to mask the relativity effect.

At this time, scientists are extremely uncertain whether this effect will be measurable. The inhomogeneity of the earth, our meager knowledge of the physical structure of the atmosphere and our lack of knowledge of the effects of magnetic fields on satellites mean that a long time may have to elapse before definitive work on the relativity effect may be undertaken. However, once these other effects are unraveled and understood then the scientist may furnish a fourth astronomical proof to the general theory of relativity.

Space-Flight Guidance

C. S. DRAPER

GUIDANCE is the process of causing vehicles to follow desired paths with respect to selected reference points. Radiation guidance depends on directional and/or distance-indicating contacts between the vehicle and the reference points. In guidance of this kind, the necessary information on physical situations is generated by using electromagnetic or sonic waves. For example, when it is possible to depend on ordinary light for contacts, systems with human operators often provide the simplest means for guidance. Radio or radar may be applied if proper equipment is available when visibility is too low, obstructions exist, or distance is too great for optical lines of sight to be effective. When the facilities for direct-contact guidance are not present or cannot be used because of natural or human interference, the nonterrestrial reference space established on the celestial sphere by visible, fixed stars is available for guidance. When this conventional navigation procedure is applied, it is, of course, necessary to have almanac data to locate the observed stars in celestial space and to know time accurately in order to take earth's rotation into account. When the guidance problem involves vehicle paths between terrestrial points, positions on the earth are associated with the indication of gravity given by a plumb bob supported on a stationary base. Observed angles between the direction of gravity and star lines of sight give the information necessary for using celestial guidance.

In situations where radiation contact between the vehicle to be guided and either terrestrial or celestial reference points is not available for any reason, it is possible to use an instrumentally established space which, in effect, is an artificial, miniature geometrical cosmos corresponding to the star-determined space of celestial navigation. The co-ordinates for this auxiliary space are realized in practice by mechanisms that apply the classical laws of mechanical inertia. Equipments based on these principles are called inertial guidance systems. In systems of this kind, the gyroscopic inertia of spinning rotors is used to detect deviations of a mechanical member from a reference orientation with respect to inertial space and to generate servo input signals for gimbal drives that hold gyro units nonrotating among the stars. Acceleration, velocity, and displacement signals in the reference co-ordinate system are provided by the resultant of gravitational and inertial reaction forces acting on unbalanced masses. Time signals to compensate for earth's rotation may be derived from any one of various devices such as molecular oscillators, crystal oscillators, tuning forks, or any other available arrangement.

Inertial Principles. Inertial-guidance equipment is not only free from the necessity of external radiation contacts but also has the special advantage of allowing complete control over the orientation of the auxiliary reference co-ordinate system. This means that it is particularly suitable for use in vehicles moving in extraterrestrial orbits either on interplanetary trips or as satellites. It is not to be expected that inertial components alone will provide guidance in space, but it is certain that the continuously available, accurate, and adjustable reference co-ordinates that are obtainable by inertial techniques will be a part of any high-performance astronautic guidance system.

Flight Control. Flight control for space vehicles of all kinds is necessary during take-offs and entrances to midcourse trajectories. Gyro units and accelerometers will certainly be used in flight-control equipment to provide reference space for stabilization and velocity vector adjustment purposes. For the limited objectives of special-purpose flights, inertial elements may be replaced to some extent by spin of the vehicle involved, but the results obtainable from instruments will dictate their use when optimum results are required.

Space-Guidance Systems. Astronautic operations provide an excellent environment for line-of-sight contacts by means of a wide spectrum of electromagnetic-radiation wavelengths. Whether or not any gain is made by converting light frequencies into other wave bands will have to be decided for each operational situation, considering the refracting reflecting, or absorbing atmospheres that may be associated with reference bodies in space. Space travel involves high speeds, great distances, and moving destinations to such an extent that there is no reason to expect that human beings can satisfactorily perform all the necessary guidance functions. Instrumental systems to realize radiation contacts automatically, geometrical references, computing results, and proper applications of vehicle control forces are essential. Human monitoring with decisions where these are needed may be required to achieve the objective of extended operations. It is of the greatest importance to engineer systems that include the optimum combination of instrumental elements and human control.

Problems of Guidance. Space guidance involves no principles of physics beyond the well-known laws of

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mechanical inertia. The techniques for realizing practical guidance systems are also at hand. Vehicle control systems, optical line-of-sight trackers, inertial-reference-member stabilization servos, slow but highly accurate feedback computing systems for the outer loops of guidance systems, and the other components required have all been demonstrated in practice. As a general rule, the necessary performance is now available in all elements and subsystems. The great need now is for space-guidance devices to be made as light and small as possible and, above all, sufficiently reliable to give high assurance that space-flight operations will be practical. The achievement of all these characteristics in actual equipment is the challenge that now exists for all members of our technological community. Electrical engineers, with their electronics, servos, computers, light-sensitive cells, radio, radar, Doppler, and many other elements, will surely play a stellar role in the realization of space flight that lies just ahead of us in the fields of science and engineering.

Dynamic Stabilization in Large Rocket Vehicles

R. E. HANNA

SOME OF THE OTHER SPEAKERS will talk about the satellite vehicles and space vehicles. I would like to talk a little about the booster vehicles that get them started, the large, high-thrust rockets that boost them up where they're going. I would like to talk about how to stabilize these things—how to get them pointed where we want them—what some of the problems in stabilizing these things are, and how these problems are likely to change in the future.

Inasmuch as the control system, which keeps the missile pointed where it is told, is only a part of the large guidance system that decides where it wants the missile to be pointed, it is only natural to assume that some of the control system requirements are imposed

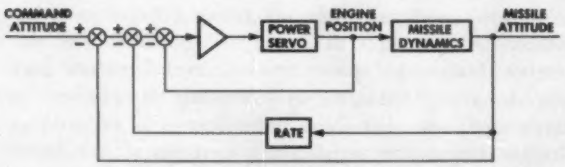

Fig. 2. Typical attitude control system.

by the guidance system. It turns out this is generally not the case. In fact, the guidance system in today's booster vehicles and probably in future booster vehicles tends to be essentially negligible in placing control system requirements. Rather, the main requirement on the control system is simply one of maintaining stability in spite of itself; that is, in spite of all the resonances and other phenomenon which are not

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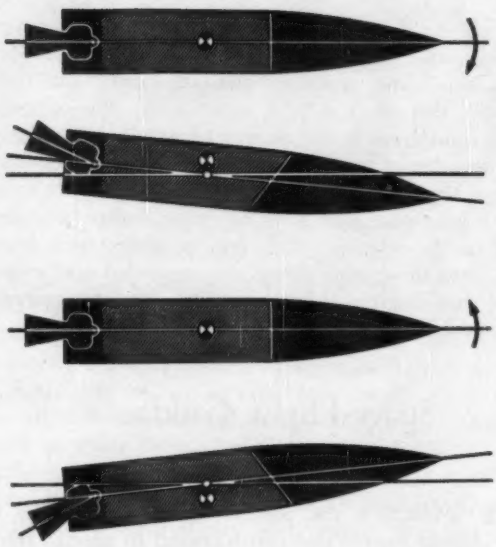

Fig. 3. Fuel sloshing.

wanted but which the control system must put up with.

I would like to touch on a few of these problems. For clarity, I will assume independence of all these problems although there is quite a considerable interaction. I will also assume for clarity a specific system—an attitude control system as shown in Fig. 2, although this system is not necessarily best for all such applications considered here. In this system, control arises from the main engine at the back of the missile, which is gimballed to provide control moments.

The first problem area concerns the aerodynamic instability which is usually present in these missiles, at least without tail fins. For a missile 60 to 100 feet long, it would not be surprising to find the center of pressure say 10 to 20 feet ahead of the center of gravity and, hence, the missile would be aerodynamically quite considerably unstable. Although large tail fins can be added to stabilize, and this is sometimes the best solution, one does not lightly add such large tail fins with their attendant weight penalty. In the absence of tail fins, a high-gain control system is required to stabilize the missile. In addition, when considering flight through the jet stream, an additional requirement for high gain is generated to prevent this disturbance from causing loss of control and/or excessive structural loading. For this condition, angle of attack feedback has some merit. It is considered that this aerodynamic instability is likely to be with us in the future although it will probably not become appreciably better or worse to handle.

The second problem area concerns sloshing in liquid tanks and the possibility of instability from this cause. Typically, liquids in a missile tank tend to slosh at a characteristic frequency, depending on the geometry involved, of about .05 to 1 cycle per second for most present and future booster vehicles. The damping ratio, incidentally, is very low on these modes, perhaps measured in the tenths of one per cent. Fig. 3 shows a time

sequence during one cycle of a sloshing oscillation, where it can be seen the missile pitching down causes the engine to deflect so as to raise the nose. The pitching down also causes the fuel to pile up on the topside, raising the center of gravity. The combination of raised center of gravity and gimballed engine rotation add together so as to add energy to the system, causing it to diverge. Fortunately, divergence occurs only in certain regions of flight (when the liquid level is between center of percussion and center of gravity), and the time constant of divergence may be long, perhaps several seconds, so that if care is taken not to excite this mode at the critical time, the divergence may be contained to acceptable values. As a result, one need not necessarily pay the penalty of absolute stability. If this solution is not sufficient, baffles can be added to improve the situation, but these are a weight penalty just as the tail fins. Otherwise, the only alternative seems to be to raise the system gain high enough so that, in effect, the system maintains control over the sloshing. Indications are that the sloshing problem will not be affected materially by future space vehicle designs, although this does depend on the individual design.

The third problem area is that of elastic bending of the body. There are many modes to be considered, the most important of which probably is the first lateral mode. Fig. 4 shows a time sequence during one cycle of a bending oscillation. Such an oscillation may occur from a few up to 10 or 20 cycles per second and again be quite lightly damped, perhaps 1 to 3% critical. At such frequencies, the rate feedback is likely to be the dominant feedback and as shown in Fig. 4, the first frame shows the normal engine response to the maximum nose-up rate indication. This engine position, however, is just such as to cause the missile to bend as shown in the second frame and, hence, cause divergence. Possible solutions to this are: (1) strengthen the entire missile, thereby raising the frequency out of the way—an impossible solution even to contemplate; (2) locate gyros or other instruments favorably, and although this can help considerably, it cannot eliminate the problem since the bending characteristics change with fuel loading and may cause other compromises to locate the instruments in the most favorable location; and (3) lower the gain and provide filters to attenuate these unwanted frequencies. This can be quite a productive possibility, particularly if one considers the whole gamut of intentional nonlinearities, digital filter, and other ingenious schemes. The over-all bending problem appears to be getting worse, particularly since the fuel fraction, currently running about 90 to 95% may well increase to 95% or above, causing the stiffness and, hence, bending frequency to decrease. This may cause the low gain needed to provide stability caused by bending to be incompatible with the high gain needed to stabilize in other respects. Clearly additional analytical treatment of these interactions is necessary to determine quantitatively the exact extent of the problem.

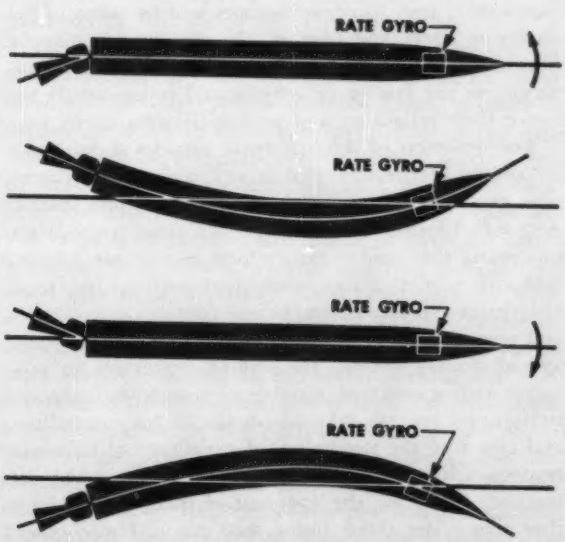

Fig. 4. Body bending.

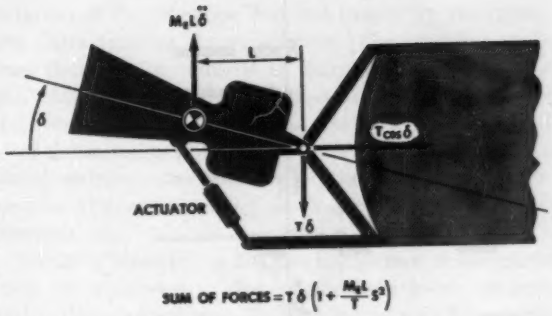

Fig. 5. Tail wags dog.

One additional problem area will be mentioned, the so-called tail-wags-dog effect (Fig. 5). The desired lateral force $T\delta$, from the deflected engine, is always reduced by the inertial reaction force $ML\ddot{\delta}$ because of engine angular acceleration. This reduction is greater at higher frequencies (and for large, off-center engines). At some frequency, typically 5 to 10 cycles per second but depending greatly on the engine configuration, there will be complete cancellation so that the engine displacement produces no net control moment. Above this frequency, there is a reversal in control.

A semiquantitative collection of most of the significant phenomenon which affect the control system stability is shown in Fig. 6. Second order effects are omitted.

To summarize, it is significant to note that the main requirements on the control system for large booster vehicles arise not from consideration of optimum response to an input, nor from minimum error in the face of a disturbance, but mainly from considerations of stability in the presence of internal unwanted phenomenon. Also, broadly speaking, we know quite a bit

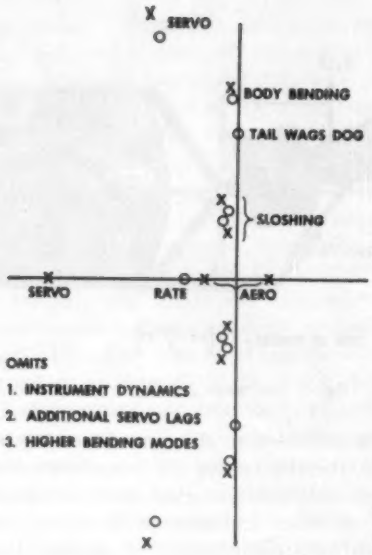

Fig. 6. Open loop pole-zero plot.

about the problem of stabilizing these booster vehicles, and we think we know quite a bit about the future trend—at least compared to many other aspects of satellite and space flight. It appears the problem on the whole is getting somewhat tougher, not so much as to cause major compromises in the over-all missile system design, but tough enough to indicate that real ingenuity is desired, possibly along the lines of intentional nonlinearities and other imaginative schemes, to provide the good stable systems which are simple enough to have the high reliability we need so badly.

Attitude Control—I

J. S. FARRIOR

THE PROBLEM of attitude control exists to a certain extent with all kinds of vehicles, missiles, and projectiles. Attitude control is necessary or desirable for at least the following reasons:

1. To provide mental and physical comfort for passengers.
2. To provide proper environment and positioning to allow instrumentation to function.
3. To provide proper alignment for lift surfaces and thrust vectors.

The human animal likes to have the resultant of the gravity, centrifugal, and inertial forces essentially in line with his backbone and directed toward the tailbone when standing or sitting. While resting, he assumes a position perpendicular to this force. In fact, these positions represent necessary conditions for stability, and the individual continuously must take corrective action if he is in a changing force field. Of course, by bracing himself and wearing shoes and trousers having a high coefficient of friction, he is able to cope with the situations existing in land vehicles, airplanes, and ships at sea.

In most cases, the undesirable motions come as a result of disturbing forces from outside the vehicle. In a space vehicle, the situation is different, and can be likened to two people walking around in a canoe. Each is convinced that the other is "rocking the boat," and they are not likely to stay on friendly terms for long. Inasmuch as the first manned space vehicles will not be very massive, and cannot afford the weight and complexity of powerful attitude control systems, they will be subjected to undesirable disturbances caused by internal, moving objects. The same is true even if the ship is rotated in order to provide artificial gravity, since these disturbances will be superimposed on the rotation.

There has been much speculation concerning the physiological reaction of man to a zero-g condition. There might also be a mental or physical reaction to an environment having a g gradient such as would be present in a ship of rather small diameter which is being rotated to provide artificial gravity.

The physiological reactions to a nonideal environment vary considerably from individual to individual. Some adapt themselves without difficulty, while others become affected to the point of being rendered unfit to perform simple duties. This would indicate that if manned space vehicles are going to have motions or other conditions causing mental or physical discomfort, an effort should be made to select as passengers people having a minimum reaction to this environment. An individual's tolerance can also be increased by administering certain drugs. Traditionally, explorers have withstood many hardships and discomforts and have not waited until first class accommodations were available. It is reasonable to assume that in order to hasten man's entry into space, advantages will be taken of his ability to "grin and bear it." In this way, it may be possible to reduce to a minimum the weight and complexity of the first space vehicles and consequently enhance their reliability and probability of success.

The designers of the first space vehicles should take advantage of the fact that a well-trained, intelligent man can serve for a better purpose than just ballast. Although limited by a long reaction time, a slow data processing rate, and a rather long access time for the mentally stored information representing his total knowledge and experience, he still contains more ability and versatility than can be built into a substitute package of similar weight. He should, therefore, be provided with a sufficient number of overriding controls, indications, etc., to take advantage of his capabilities and give him the psychological advantage of having a responsibility and of feeling that he is master of the machine. After all, the conquest of space should infer that man is out there, living, and doing things; otherwise, we may as well continue to send unmanned vehi-

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cles into space. Of course, in time, when space travel has become commercialized and is simply a routine means of getting from one planet to another, the emphasis can be placed on the luxury liner concept, at least as far as the paying customers are concerned, with comfort and entertainment—first, second, and third class.

Although man, himself, may tolerate a great deal of unsteadiness on the part of the space vehicle, certain instrumentation will be much more demanding. For instance, astronomical measurements having to do with navigation will require directional alignment of sensing devices to a high degree of accuracy. Fortunately, this problem can be separated to a large extent from the problem of attitude control of the space vehicle as a whole. This is not a new concept, and originated with the ancient navigator on deck using a hand-held sextant, or its early equivalent. In this case, an effort is made to stabilize the measuring device to the necessary accuracy, and the requirements for ship's stability are set by such considerations as comfort and safety. Modern ships, airplanes, and missiles using star trackers for navigation have the tracking telescopes mounted on a stabilized platform and do not require extreme accuracy of the vehicle stabilization.

The foregoing comments have applied to manned space vehicles or those having internal parts of significant mass which are undergoing translational motion or changing rotational motion. In the case of certain types of unmanned space vehicles, satellites, or large antennas or telescopes in space, it may be desirable to stabilize the entire body.

It is well known that astronomical observations made from outside the earth's atmosphere will give a resolution and wavelength coverage far in excess of that obtained by earth-mounted instruments. Even in the field of radio astronomy, improvements can be made by using an extremely large antenna and by being able to place all earth-generated signals on the back side of the antenna.

The first space astronomy will be limited to viewing and photographing the moon, sun, and planets using small apertures and short exposures. Later, in order to further the study of the origin and destiny of our universe, it will be necessary to extend these observations to the distant nebulae and galaxies, a much more difficult task requiring large apertures and long exposures.

A satellite observatory will consist of two main parts: a vehicle for living and working quarters, and the telescope which can be physically separated from the vehicle during operation. The telescope will be capable of automatically acquiring and tracking the area to be photographed, as well as automatic focusing and film handling. Problems encountered with earth-mounted telescopes caused by the polar-axis bearing and drive, the changing refraction of the atmosphere, and deformations resulting from the mass of the instrument will of course not be present. The problem of maintaining uniform temperature of the reflector may be more difficult. In the case of stars or other "fixed" bodies, all apparent motion will be entirely the result of absolute rotation of the telescope and not caused by the changing characteristics of the medium. The tracking problem, therefore, is reduced to maintaining the axes of the telescope truly direction-fixed in space. This means that very small gyros or inertia wheels will be required after the initial alignment has been accomplished. Television techniques will be employed in remotely controlling the telescope and in making certain types of observations.

Satellites intended to observe the surface of the earth must be positioned so that this is done in an efficient and predetermined way. Various techniques have been proposed such as horizon seekers, schemes which use the shadowing effect of the earth, cosmic radiation, and gravitational torque or tidal forces such as described in papers by Roberson and Oberth.

Communication between the earth or other planets and space vehicles or between space vehicles must be conducted over vast distances. In order to keep the information rate reasonably high and the power requirements reasonably low, antennas having very narrow beam widths will be used. Such antennas must be kept accurately aimed.

Space vehicles of the future may start their journey from a satellite orbit and utilize low-thrust propulsion such as obtained from an ion rocket. It will be necessary, in this case, to keep the space vehicle aligned so that the thrust vector is in the desired direction. If the ion rocket is using electricity generated from solar energy, the large energy-gathering surfaces must be kept in the proper position with respect to the sun.

Although most attitude control systems for space vehicles will operate without the expenditure of mass by employing gyroscopes and spinning wheels, these devices probably will be supplemented by small rocket motors or jets to handle disturbances such as those caused by the separation from the final propulsion stage.

Space vehicles must be propelled in some way into space and this means that they, or their component parts, must be transported through the earth's atmosphere. The problems of attitude control during this phase may be considered to be outside the scope of this symposium. However, certain types of space ships must return safely to earth, and this introduces a number of control problems. In principle, this problem becomes one of positioning the vehicle during a propelled phase in order that the thrust vector will be oriented in the proper direction, and then, after re-entry, controlling the attitude so that the proper combination of lift and drag forces result to keep the deceleration and aerodynamic heating within acceptable limits.

The field of control engineering has seen amazing advances in recent years. The control engineer is armed with powerful analytical tools and a wide variety of available components and techniques to apply toward the solution of space problems. Attitude control is, of course, only a small part of the control engineer's domain and, in addition, he will find himself faced with

problems of temperature control, atmosphere control, and reprocessing of body wastes. Because of the high cost of transporting materials to the moon or to other planets, the first living quarters are likely to resemble a balanced aquarium with solar energy being almost the only input. The same also applies to space vehicles making extended voyages.

Although the control engineer may feel that at present he has available solutions to most of the problems, he must realize that present techniques are far from satisfactory from the standpoint of performance, size, weight, and especially reliability. The integration of this complex of equipment into the space vehicle in the optimum way will remain a colossal challenge to this and future generations of astronautical control engineers.

Attitude Control—II

R. E. ROBERSON

CONTROLLING THE ATTITUDE of a satellite vehicle should be a simple job. The body behaves as if it were suspended on a frictionless pivot. Control torques can be small. There usually is no need for extreme precision in measurement. And adequate response times are ridiculously low by conventional servo standards.

As a matter of fact, though, if examination is made of the foundations of the problem carefully, it turns out to be one of the nastiest control problems imaginable. A whole set of special problems arises in the synthesis to plague the control system designer, even before he gets to the hardware stage. And then, of course, he is confronted with all the physical constraints and environmental problems unique to space equipment.

Today, I will talk about synthesizing a system for satellite attitude control. Inertial control devices will be emphasized and the nature, difficulties, and status of the synthesis problem described for this case. A few typical control results that have been obtained for one specific example will be shown.

It is important to list six major problem areas of satellite attitude control to give a working framework for the discussion to follow.[1-4]

1. *Selection of attitude reference frames relative to the mother planet and within the body of the satellite vehicle.* There is no natural choice of attitude reference system which does not either wobble around and contribute an inertial reaction perturbing torque on the vehicle, or else put the vehicle in an unfavorable orientation relative to externally imposed perturbations.
2. *Analysis of torque sources and magnitudes.* Torques are small by terrestrial standards, but it does not take much to disturb a satellite. The nature of the torques, the way they enter the dynamical equations, can play a dominant role in attitude control.
3. *Development of a complete set of dynamical equations for the vehicle motion.* This is more difficult than might be expected, especially when the satellite is assumed to have internal moving parts.
4. *Conception and analysis of methods for sensing vehicle orientation.* For some systems it may be necessary to measure absolute orientation. For others, where inherent system stability already exists, it may suffice to measure attitude rates.
5. *Conception and analysis of methods for applying attitude control torques.* A variety of control actuators can be imagined. The most important undoubtedly are the methods which depend on the inertial reaction of matter expelled from or moved about within the vehicle.
6. *Synthesis of a control system.* This process establishes the transfer or filter function relating the sensed orientation and rates to the input signal sent to the control actuator.

It is the inertial methods and the control system synthesis that will be discussed.

Numerous physical phenomena contribute to the perturbation torques on the satellite's orientation. Most also can be used to produce a controlling torque. Not all methods are satisfactory, of course. Some give torques that are too small; some have limited angular momentum capacity (i.e., can be easily saturated). Others are unattractive because they are hard to mechanize. The one class that appears best by most performance criteria is that of inertial methods.

These can be realized by gas jets, for example, or spin stabilization of the entire vehicle. But my remarks will be confined to methods which depend on translating or rotating parts within the vehicle. There are many possibilities, such as passive vibration absorbers, fixed speed flywheels in gimbals (like a gyrostabilizer), or variable speed flywheels in fixed bearings.[5]

The variable speed flywheels, often called acceleration wheels, can be made the basis of a particularly flexible and efficient attitude control system. Basically, they function in the following manner. If the vehicle is tending to turn about one of its major body axes, this tendency is detected by the attitude sensing system. A signal is sent to the wheel which turns about this axis to accelerate in the same sense that the vehicle is turning. The angular acceleration of the wheel relative to the vehicle frame applies an inertial reaction torque on the vehicle in the proper sense to oppose the original vehicle rotation. Three wheels can be used to get control about three body axes. Actually, because roll and yaw modes are coupled in an orbiting vehicle, a single wheel can be made to serve for control about both of these axes.

To see what the control system synthesis problem consists of, we have to examine the dynamical equations describing the attitude motion. They are

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$$\left.\begin{aligned} &\frac{d}{dt}\,(\bar{\bar{I}}\cdot\bar{\omega}) = \bar{L}_{EXT} - \bar{L}_P\,(\bar{\omega};\,t) - \bar{L}_C \\ &\bar{\omega} = \bar{\omega}\,(\theta_1,\,\theta_2,\,\theta_3,\,\theta_1,\,\theta_2,\,\theta_3) \end{aligned}\right\} \quad (1)$$

Here

ω = angular velocity of vehicle relative to attitude reference axes

$\theta_1, \theta_2, \theta_3$ = attitude deviations relative to this reference (roll, pitch, and yaw, respectively)

$\bar{\bar{I}}$ = constant part of inertia dyadic

$\bar{L}_P$ = Parametric excitation torque

$\bar{L}_C$ = control torque, a function of $\bar{\omega}$, t as well as the variable parts of the moments of inertia, the relative angular motion, and the translation of internal parts.

For the variable-speed flywheel system, the control torque takes a much simpler form, depending only on $\bar{\omega}$ and the angular speeds of the flywheels relative to the vehicle frame.

The control system synthesis problem is essentially the following: The torque $\bar{L}_C$ in equation 1 is to be chosen as a function of measured attitude deviations and/or rates so as to "best compensate" the effects of $\bar{L}_{EXT}$ and $\bar{L}_P$. This immediately raises a question as to the design criterion. The control system certainly should keep attitude motions small in some sense, but what does this really mean quantitatively? This question is a major problem area by itself. Although it is central to the synthesis problem, it must be reported that it has been largely ignored in the literature.[1]

Even after a criterion is decided, it remains to choose the functional form of $\bar{L}_C$ (in terms of θ_1, θ_2, θ_3 and their derivatives) and values for the parameters that appear in this function. This choice is the core of the synthesis problem. It is a difficult step. Equation 1 has several characteristics which make the synthesis problem one of considerable delicacy.

1. Even ignoring the term $\bar{L}_P$, the equations for θ_1, θ_2, θ_3 are inherently unstable. At best, when stabilizing terms are introduced through $\bar{L}_{EXT}$, the equations become conditionally stable.

2. When conditionally stable, the equations have very long natural periods, of the order of hours to months.

3. There is intermode coupling among roll, pitch, and yaw, so that the control synthesis pertains to a high order system. Even ignoring small coupling through $\bar{L}_P$ and nonlinear terms, the roll-yaw coupling remains as an essential characteristic of the problem.

4. There is inescapable parametric excitation of attitude motions. No choice of attitude reference or orientation angles can remove the term in $\bar{L}_P$ that depends explicitly on time.

5. The equations for the attitude deviation angles are nonlinear, although they do reduce to a linear approximation for small oscillations about the reference axes.

The problem of synthesizing a control system rationally for such a system (i.e., the problem of choosing a "best" functional form for $\bar{L}_C$, has not been solved as far as I know. As a practical matter, one must simplify the problem. My own philosophy has been to proceed as follows: Although the parametric and nonlinear terms cannot be ignored in any careful treatment, in many attitude control problems their amplitudes are quite small. In this case, discard them temporarily to obtain a linear system with constant coefficients. It is amenable to the usual techniques of servo synthesis, which yield a control function and parameter values. Now using these values for a tentative control system, return to the problem in its most general form and determine the system response to expected excitations. If these are tolerable, stop. If they are not, there is no pat solution other than to cut-and-try by parameter variation about their tentative values. This technique leaves a lot to be desired, and a better one would be welcome. However, it may give useful, if not optimum, answers in many cases.

So much for the general problem. I now would like to show an illustrative example for the control of small attitude oscillations using reaction flywheels as the actuators. Unfortunately, time does not permit a complete discussion of the example. I can merely display the basic equations that one has to work with, mention the nature of the control system input in terms of sensed information, and show a few typical response curves.

Following the philosophy outlined, the basic dynamical equations take the forms of equations 25, 27, and 28 of a previous article of mine.[1] The control torques from reaction flywheels are added as in equations 30 and 31 of another article[5] to obtain the complete system.

$$\begin{aligned} &I_X\,\ddot{\theta}_1 + \Omega^2\,[4\,(I_Y - I_Z) + I_H]\,\theta_1 + \Omega\,(I_X + I_Z - I_Y + I_H)\,\dot{\theta}_3 \\ &= L_X - (\dot{H}_I + \Omega\,H_3) \\ &I_Y\,\ddot{\theta}_2 + 3\,\Omega^2\,(I_X - I_Z)\,\theta_2 = L_Y - \dot{H}_2 \qquad (2) \\ &I_Z\,\ddot{\theta}_3 + \Omega^2\,(I_Y - I_X + I_H)\,\theta_3 - \Omega\,(I_X + I_Z - I_Y + I_H)\,\dot{\theta}_1 \\ &= L_Z - (\dot{H}_3 - \Omega\,H_1) \end{aligned}$$

Here

I_X, I_Y, I_Z = moments of inertia about body principal axes

Ω = orbital angular frequency

L_X, L_Y, L_Z = components of all torque except parametric and nonlinear excitation torques temporarily neglected[6]

H_1, H_2, H_3 = spin angular momentum of flywheels which rotate about X, Y, Z axes respectively, relative to the vehicle frame

I_H = an equivalent moment of inertia such that $\Omega\,I_H$ is the constant component of the net angular momentum of all internal parts (relative to the vehicle frame), assumed oriented along the pitch axis.[1]

In the absence of control, equations 2 are condi-

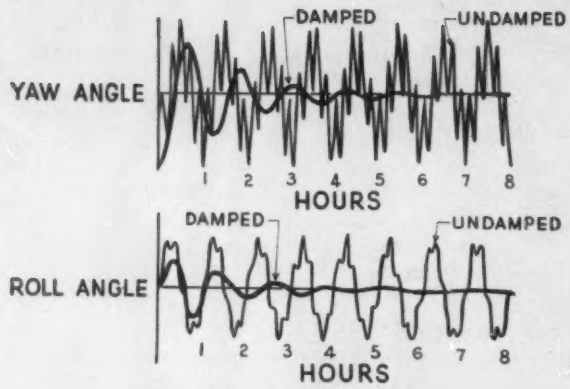

Fig. 7. Typical response to an initial yaw angle.

tionally stable provided certain inequalities are satisfied by the vehicle moments of inertia (for example, $I_Z < I_X < I_Y$ in the case $I_H = 0$). This suggests that a simple control system might result merely from putting rate signals into the control wheels to provide damping in Equations 2. In effect, the driving voltage applied to each flywheel is made proportional to the output of a corresponding rate gyro. Actually, things are not quite so simple. To prevent attitude error buildup from gyro bias, some integral control is desirable. Or else, one might use a dead zone about zero angular velocity, which also can be beneficial in conserving power. It appears that in this simple case, at least, improved transient response can be obtained if the roll wheel is deleted and roll control is obtained through coupling with the yaw mode which does use a control wheel.

Some response curves are shown in Figs. 7 and 8. Fig. 7 shows yaw and roll response to an initial yaw angle; for example, one that might be present at the establishment of the satellite orbit. The removal of such initial conditions is the first job the attitude control system must do. Fig. 8 shows yaw and roll response to a yaw impulse. Physically, this might correspond to an initial yaw angular velocity, to the impact of a meteoroid creating a torque about the yaw axis, or to the sudden rotation of some internal moving part (such as an antenna, for example) about the yaw axis.

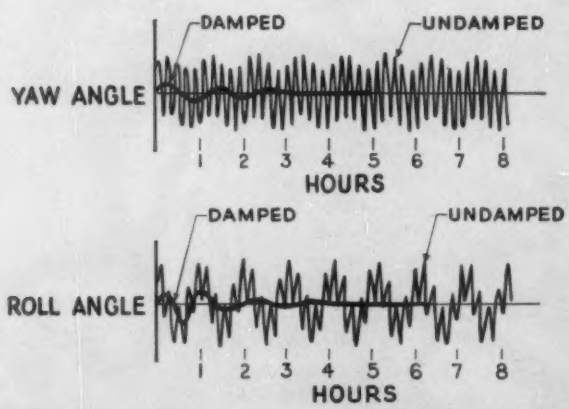

Fig. 8. Typical response to a yaw impulse.

Although these results are typical, they are far from complete, of course. Time does not permit showing the response to other kinds of yaw excitation, or the corresponding results for the pitch and roll modes. Nor have I discussed the effects of instrument errors or the neglected parametric excitation and nonlinear terms. These topics must wait upon the separate publication of the servo analysis details for this particular example.

Nevertheless, I feel that the outline given here is a fair survey of a useful approach to the synthesis of an inertial control system for satellite attitude.

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Attitude Control—III

D. B. DE BRA E. V. STEARNS

THE AGE OF SATELLITES is here. With it has come some interesting attitude control problems. For many uses, it is desirable to have a satellite oriented in a unique attitude with respect to the earth. If such a unique stable attitude exists, the attitude-control problem is reduced to a damping problem. Two methods have been proposed to obtain a stable attitude. These methods use (1) the gradient in the earth's gravitational field, and (2) aerodynamic torques. Each method requires that the vehicle have certain properties. In gravity gradient stabilization, it is necessary that the vehicle have a single axis about which the moment of inertia is a minimum. In the stabilized position, this axis becomes aligned to the vertical.[1-4] In aerodynamic stabilization, it is necessary that the center of pressure lie behind the center of mass in the direction of the vehicle's velocity.

It is difficult to design a vehicle so that either gravity gradient or aerodynamic torques are missing. When stabilization is attempted, utilizing one effect, disturbances may be introduced from the other.

To illustrate this problem, two nominal vehicle designs have been chosen and are illustrated in Fig. 9.

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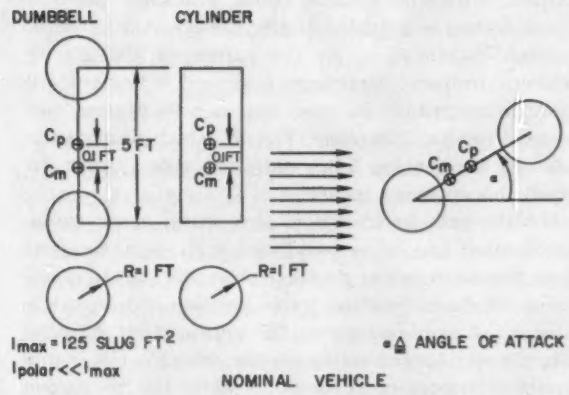

Fig. 9. Two nominal vehicle designs.

The geometries are distinct, but for simplification, the physical properties have been chosen to be the same.

The problem considered here will be the evaluation of the torques required (if any) in maintaining a given attitude for the two vehicles in a circular orbit under the influence of a gravitational field and a model atmosphere.

Aerodynamic forces at the altitude of interest (above 80 statute miles) make a study in themselves. The computation of drag based on free molecular flow is complex. A good approximation can be made assuming Newtonion flow however, if the molecular speed ratio is sufficiently high. Newtonian flow has a drag coefficient which is two; therefore, when the drag coefficient based on free molecular flow approximates two, the assumption of Newtonian flow yields reasonable results. Curves a and b in Fig. 10 present a method of determining in what range of altitude this approximation can be used. The drag characteristic plotted is for a sphere but the shape of the curve is characteristic. The assumption of Newtonian flow is, therefore, justifiable for altitudes less than 375 statute miles for accuracies on the order of 10%. Theoretically, it is necessary that the Knudsen number be greater than 10 to justify free molecular flow. The Knudsen number is the ratio of particle mean-free-path to a significant vehicle dimension. From experimental results however, it appears that the flow is essentially free molecular for Knudsen numbers greater than two. For the vehicles under consideration, the Knudsen number is approximately five at an altitude of 80 statute miles and increases rapidly above that altitude.

The computations are based on Newtonian flow and are a good approximation between 80 and 375 statute miles altitude.

Consider a vehicle stabilized by the gravity gradient with $\alpha = 90$ degrees where α is defined in Fig. 9. For the assumed separation of center of mass and center of pressure of 0.1 foot, the torque required of a control system is shown in Fig. 11. This implies a constant torque must be produced by the control system in order to maintain position, or the vehicle will rotate toward the position in which the gravitational gradient torque balances the aerodynamic torque. Since a control system that produces a constant torque is expensive in weight and power, the attitude error that can be tolerated determines the minimum altitude of a circular orbit when constant control is not used; e.g., for the cylindrical vehicle used in this study, a one degree attitude error implies a minimum orbit altitude of about 330 statute miles, if the control system is not capable of a sustained torque.

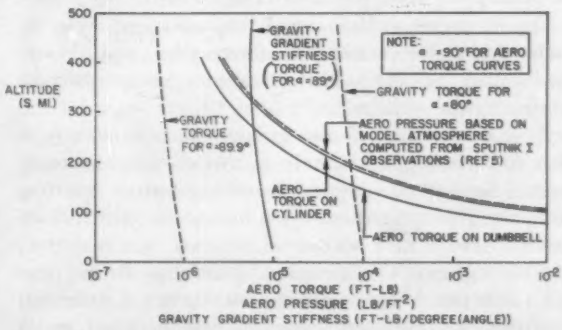
ALTITUDE (S. MI.)
GRAVITY GRADIENT STIFFNESS TORQUE FOR α = 89°
NOTE: α = 90° FOR AERO TORQUE CURVES
GRAVITY TORQUE FOR α = 80°
GRAVITY TORQUE FOR α = 89.9°
AERO PRESSURE BASED ON MODEL ATMOSPHERE COMPUTED FROM SPUTNIK I OBSERVATIONS (REF 5)
AERO TORQUE ON CYLINDER
AERO TORQUE ON DUMBBELL
AERO TORQUE (FT-LB)
AERO PRESSURE (LB/FT^2)
GRAVITY GRADIENT STIFFNESS (FT-LB/DEGREE(ANGLE))

Fig. 11. Torque required of a control system with an assumed separation of center of mass and center of pressure of 0.1 foot.

In the model considered, it could be argued correctly that the deviation from the vertical could be planned on and it should not be considered an error. For a satellite, however, the aerodynamic forces are not constant as they are in this model. Normal fluctuations in the atmosphere and variations in the vehicle altitude cause a variation in the equilibrium position. Inasmuch as the variations may be of the order of the deviation from the vertical, the deviation is treated as an error.

The aerodynamic pressure decreases with altitude but theoretically never vanishes. Therefore, there is no altitude at which the equilibrium attitude of a vehicle exactly coincides with the vertical if there is an area moment about the center of mass that can produce an aerodynamic torque. The error becomes vanishingly small, however, for high altitudes.

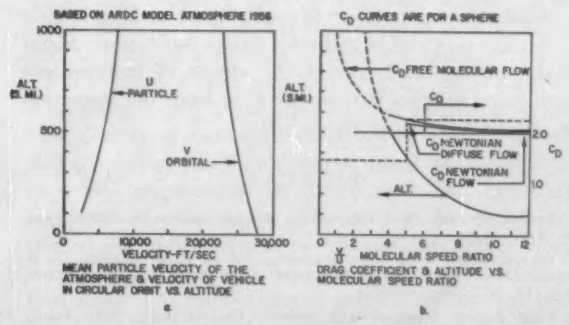

Fig. 10. Method of determining range of altitude for drag approximation.

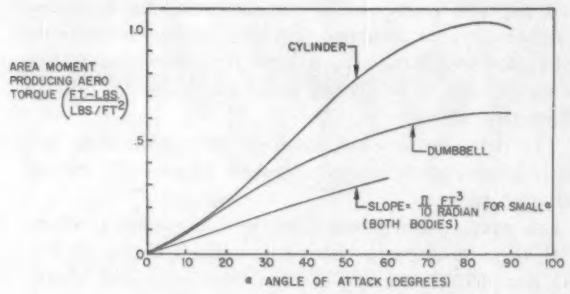
AREA MOMENT PRODUCING AERO TORQUE (FT-LBS / LBS/FT²)
1.0
.5
0
CYLINDER
DUMBBELL
SLOPE = π/10 FT³/RADIAN FOR SMALL α (BOTH BODIES)
0 10 20 30 40 50 60 70 80 90 100
α ANGLE OF ATTACK (DEGREES)

Fig. 12. Area moment vs angle of attack

When a vehicle is stabilized by aerodynamic effects ($\alpha = 0$) at a given altitude, the restraining force is a function of the deviation, and the frequency of oscillation about the equilibrium position becomes a method of comparing the stiffness of constraint for small deviations. Corrective torques are caused by aerodynamic pressure on an area that has a moment about the center of mass. The area moment is proportional to restraining torque and is plotted (Fig. 12) for the two vehicles being considered. The slope of the area moment is the same for both vehicles near $\alpha = 0$ because the area they present to flow in that position is the same and they have the same moment arm.

Fig. 13 presents the natural frequencies of these vehicles for small oscillations about their equilibrium position in the absence of all torques, except the constraint torque indicated.

A characteristics of the gravity gradient torque is that it varies approximately as the sin (2α). In other words, there is no constant disturbing torque resulting from the gravity gradient when one of the vehicles considered here is in a horizontal position ($\alpha = 0$ degrees or 180 degrees). This does not mean that the position is a stable one. When α is near 180 degrees, the slightest disturbance allows both the aerodynamic and gravity torques to increase the deviation. This condition is clearly unstable, but the situation near $\alpha = 0$ degrees is not so obvious. At α near 0 degrees, the restraining torque caused by the aerodynamic forces may be less for small deviations than the gravity gradient torques.

The crossover point, where the aerodynamic restraining torques equal the gravity gradient disturbing torques, defines an altitude below which the position $\alpha = 0$ degrees is a stable equilibrium position for aerodynamic stabilization. By the nature of the gravity gradient torques, the effects near $\alpha = 0$ degrees are equal in magnitude to those near $\alpha = 90$ degrees, but reversed in sign. Therefore, Fig. 13, which displays the natural frequencies, also indicates the altitude at which this crossover occurs.

For the vehicles chosen in this study, aerodynamic stabilization can be accomplished with no theoretical error for orbits below approximately 120 statute miles.

Fig. 14 shows how the stable position can be calculated for a dumbbell above 120 statute miles, by plotting the net torque acting on the vehicle. The stable equilibrium position is the point where the net torque passes through zero with positive slope.

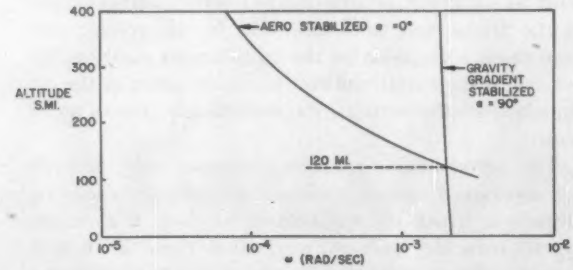

Fig. 13. Altitude vs natural frequency of vehicle for gravity gradient acting alone and aerodynamic forces acting alone.

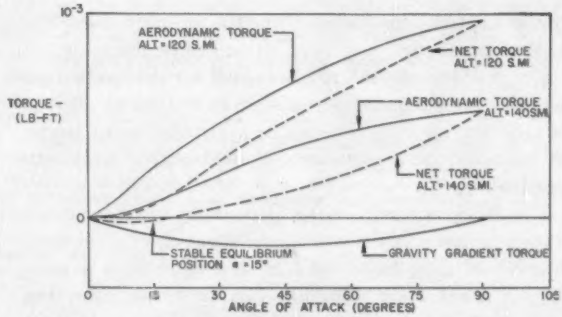

Fig. 14. Angle of attack vs torques acting on dumbbell.

It should be emphasized that the results presented are for given vehicles and differ markedly as the vehicle characteristics are changed.

If a vehicle is designed specifically for gravity gradient stabilization, it is likely that a center of mass-center of pressure separation could be kept to less than 2% of the vehicle length. Similarly, aerodynamic stabilization could be achieved more readily in a vehicle designed to have nearly constant moment of inertia about all axes.

Attitude control systems can force a vehicle to maintain any position, but in a satellite vehicle, which is expected to have a relatively long life, the power requirements may be prohibitive. Vehicles may be designed having a stable equilibrium position. For this type of vehicle, the control system must assist a vehicle in attaining a stable attitude, damp oscillations about that position, and correct the effects of intermittent disturbing torques that might arise from the operation of equipment within the vehicle.

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System Design

J. L. BOWERS

A GREAT DEAL OF ATTENTION is being paid to the celestial mechanics of space flight and the synthesis of systems to control space vehicles, satellites, and missiles. However, no less important is the problem of the practical design and construction of the vehicles and control hardware which will be required to realize our current potentialities in meeting the challenge of space travel. The scope of the discussion to follow will be restricted by omitting consideration of specific instruments, such as inertial components, platforms, etc., and concentrate on the over-all problem of electrical and mechanical design of parts, components, and systems. Consideration will be given to the physical design of control systems as well as power systems required to provide motivating energy. The attributes of reliability and accuracy will also be treated insofar as they affect the aforementioned topics.

The current state of the art in control systems for vehicles suitable for space flight has evolved from our missiles programs. Tremendous advances have been made in the last 10 years both in the philosophy of design as well as physical design. In the philosophy of design, there has been a strong trend toward the system approach, and the requirements for reliability have had an overriding effect on all features of design, test, and operation. The World War II approach was characterized by the attempt to standardize electronic equipment in specific sizes and shapes and, in so doing, the basic mechanical construction was fairly well formulated. Each aircraft was an assemblage of separate systems which were designed independently but all too often displayed their lack of independence when one tried to make them operate correctly at the same time. This approach is being superseded by system designs which are tailored to the specific task at hand with more and more attention being paid to the interrelationship of various subsytems. However, the importance of the system concept has not been fully recognized by all design agencies, or at least they do not know how to go about it, and there is still room for a significant amount of learning. One great lesson learned in the missiles programs has been that systems must be designed for extensive ground operation as well as flight; and, in order to achieve significant reliability, very long life is inherent in the required design even though the missile life is only a few minutes. The missile programs have developed a design technology in which a greater and greater use has been made of metal castings (aluminum and magnesium) on which to mount electronic and control components. The castings have provided rugged assemblies capable of withstanding severe vibration environments and have also served as satisfactory heat sinks. The application of printed circuits has been developed to a highly successful state and the use of semiconductors has developed more rapidly than was initially predicted. (It was thought earlier that temperature characteristics would inhibit application to military articles which typically have severe environmental requirements.) An early trend was established toward the use of potting; however, it has lost momentum and it is predicted that this type of construction will be utilized only to solve specialized problems. Potting adds weight and satisfactory rigidity can be obtained by other approaches. Potting remains one of the superior methods in combating humidity.

With this general missiles background, the first ballistic missiles have been designed. A satisfactory state of the art from which to obtain reliable operation has been developed; but the increased importance of weight has indicated a need to evolve lighter construction methods which can still be made to withstand the expected environments. It is certain that in our interest to exploit space-flight capabilities, the current ballistic missiles will be used and, therefore, they will initially be dependent on the current relatively rugged and heavy military designs. Printed circuits will be used extensively and semiconductor devices will become the predominant elements used for signal conditioning and power conversion. This, then, will be the expected configuration of the first generation of space vehicles. However, it costs many thousands of dollars per pound to project equipment into space and, so, in the interests of economy and performance, the major design effort for the second generation of space vehicles will be applied toward weight reduction. In order to give practical definition to what is meant by first and second generation, the following examples are cited: The control and instrumentation designs which were synthesized for the Vanguard program are exemplary in size and weight of those which will be seen during the second generation. The appearance of such designs in a period which must be termed the first generation, was forced by the minimum energy available from the Vanguard booster. On the other hand, the first space achievement with appreciable amounts of equipment will use missiles in the Jupiter and Thor category and the programs will really come of age with the use of boosters the size of the Atlas missile. These programs will not have such severe weight restrictions and are classed as the first generation of space equipment design. The true second generation of space equipment will come into being with the continuing use of boosters of the Atlas size, enhanced with super fuels and with high-performance additional stages. The electronic and control equipment for these vehicles will exhibit a trend toward microminiaturization requiring improved hardware techniques. There will be a greater use of sheet-metal construction including deep drawn cans and extensive use of sandwich material and phenolics. The current developments in small connectors will be continued and electric cabling will utilize light high-strength wire such as Copperweld, and the printed circuit approach to solving the cabling problem will continue in its development.

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It is probably prudent to take a pessimistic view regarding additional conditions which may be imposed in achieving satisfactory designs for control systems. In other words, as we learn more about space environment, the design problem will probably increase in severity—not decrease. For example, one of the more exotic simplifications which has been suggested is that vacuum tubes in a vacuum will need no envelopes; the fallacy of such hopeful thinking is obvious. There has been recent concern over a large amount of radiation which has been encountered at certain altitudes; however, the amount of radiation currently being measured should not seriously affect the operation of the elements which are known to have susceptibility to this environment. (Tests on semiconductors, vacuum tube cathodes, lubricants, etc., show that much higher radiation is required to alter their characteristics.)

One of the most important considerations is power generation. Vehicle requirements can be roughly separated into three categories: missile applications and short-term satellites which will require relatively low total energy, longer duration satellites for which operation may extend into months and, finally, power systems required for interplanetary travel. Either batteries or auxiliary power systems utilizing hot gas turbines are satisfactory solutions for the first requirement; however, there will be a real controversy for the longer duration vehicles. Batteries will continue to be used until sources are developed with superior efficiency or systems are perfected which can tap otherwise unused sources of energy. Approaches such as fuel cells may provide the higher efficiency solutions, while solar batteries and thermopiles may be considered for the latter category. The solar battery appears to be ideally suited to the space environment but will offer problems in collecting sufficient energy which is coupled with a rather low efficiency. Thermopiles have discouragingly low efficiency and may find no application for this reason. Until completely satisfactory solutions are found for power sources, intermittent operation will be one method of conserving total energy. For extremely long-range vehicles, where various forms of nuclear energy may be employed, more efficient sources of energy storage may be a by-product of the propulsion system.

Something has been already said about the effects of reliability requirements on current designs. Although the over-all problem of reliability will continue to be a headache, particularly in keeping missiles ready to fly on short notice, significant demonstration has been made that it is possible to attain satisfactory degrees of reliability in flight in both airborne missiles and ballistic missiles. In the Atlas program, for example, there have been almost no reliability problems experienced during the flight regime, despite the fact that a significant number of control systems and instrumentation systems have been combined to make the total complement of vacuum tubes and other critical components extremely high. (This has been achieved by careful rugged design and meticulous inspection and test during manufacture, including application of vibration and the use of parts purchased to restrictive specifications.) Instruments and all electromechanical devices seem to provide a large measure of problems in the guided missile programs; but, it is predicted, they will be improved or replaced wherever possible by semiconductor devices. Concentrated effort on the remaining required electromechanical components are producing satisfactory designs. An often discussed, but infrequently utilized, approach to reliability is that of redundancy. It is possible that on very long flights, in unmanned vehicles, this technique may become useful. As was mentioned before, it is felt that sufficient reliability can be attained without redundancy on short-range missions and on manned missions, long or short, redundancy would probably not be required.

The problem of accuracy is too broad to discuss at length but it will suffice to say that there is an ever-increasing trend toward digital solutions for control and computations. The advent of semiconducting devices has made this a realistic possibility. Analog approaches have continued to appear satisfactory for most actuating systems but, even in this area, considerable thought is being applied to digital systems or those types that may be characterized as "bang-bang" systems. As a general application, it is predicted that analog computation methods will never be used. They may make a brief appearance in some systems but will probably be superseded very quickly in most cases and with them will go all but the very few, absolutely necessary, electromechanical devices. It may be seen that both the requirements of reliability and accuracy have combined to force this aspect of our design evolution.

It has been shown that the present state of the art in the design of space vehicles is based on the evolution of missile programs. It is characterized by rugged electronic equipment construction which has been designed for extreme environment of vibration and temperature and has made use of printed circuits with an ever-increasing application of semiconductor devices. Even in systems utilizing large numbers of vacuum tubes, satisfactory reliability has been demonstrated. There will be increasing emphasis on weight reduction through the use of phenolics, sandwich construction, and sheet metal in replacing the casting techniques. The digital approach to computation requirements will very quickly become universal. Electromechanical devices will disappear, except for specialized, sensing instruments, particularly inertial components and platforms. Batteries will continue to be used as a source of power but concentrated development will be applied in other areas, such as hot-gas turbines, fuel cells, solar batteries, thermopiles, and applications of nuclear energy.

Discussion Transcript

Question:

Would Dr. Draper comment on the usefulness of inertial guidance in regard to accuracy and reliability?

Dr. Draper:

There are two phases to the problem of stabilization: one is the geometrical stabilization of the vehicle itself, that is, keeping the vehicle under control in the sense of constraining it from undesired motions, and the other is to provide for controlled adjustments of the velocity of the vehicle. In every case, I believe that you would have recourse to spinning wheels as the means for accomplishing geometrical stabilization. These spinning wheels establish a slowly moving set of reference coordinates that tends to hold its orientation with respect to the stars.

Now, if you are going to control the vehicle (I call this flight control), you do not, in fact, have to have what you would call high performance of the equipment from the standpoint of drift characteristics. I define drift as the deviation, and drift rate as the rate of deviation, that the gyros allow the element they stabilize to have with respect to inertial space, which is effectively established by the stars. Various manufacturers now supply components that may be used for geometrical stabilization. Various levels of performance are available. You can reasonably expect to find gyro units with drift rates of the order of 1/100 of a degree per hour; you can expect to get this in devices that will run for a long time and will not weigh over a few ounces. Units of this kind can provide stabilization for the flight of complete vehicles.

There is another form of stabilization that must meet more rigid requirements than those associated with flight control. This is stabilization of the inertial reference co-ordinates used for the purpose of accurate inertial guidance. If you can see some references—stars, the earth, or whatever object is taken as the destination—you can look out and get information that will supply guidance. However, radiation contacts of the visual type or any other kind must be supplemented by the use of stabilization equipment designed to average the inertial-space rates of the lines of sight, if instead of 1/100 of a degree per hour, you may be concerned with drift rates less than one degree per year. Because of security classification I will not quote any number closer than this approximate example.

I would like to add to the remarks that have been made on the subject of reliability. It is, in fact, impossible to make a highly accurate piece of equipment that does not at the same time have a long life, that is, unless you deliberately blow it up or destroy it in some other way. I used to work in the watch industry. The pocket watches that were manufactured were not only very accurate but also had such long lives that the industry soon saturated the market. I am sure that a good many of you here in the audience have in a drawer somewhere watches handed down from your father or grandfather that still run very well. The reliability problem and the accuracy problem I think are technically within our grasp, although there is some question as to whether or not an accuracy corresponding to a drift rate of one degree per year or less is actually achievable.

I would also like to make the point that only a small amount of power will be available on space vehicles for some time to come. This means that from the standpoint of equipment design you must strive not only for performance and reliability, but also for operation with minimum power consumption. In my opinion, there is much development to be carried out in the direction of devices with high performance and low power consumption. The first goal must be satisfactory operation; afterward, a balance must be struck between cost on the one hand and small size with low power consumption on the other. These features will certainly be expensive in terms of effort and money.

Question:

Is Sputnik III tumbling, spinning, or stabilized in any way?

Mr. Farrior:

Well, I'm not very much of an authority on the Soviet satellite, but my guess is that it is tumbling; I'm pretty positive that it is. I doubt that they do have any control, and in fact, our own satellite is tumbling.

Mr. Hanna:

I might add one comment. There is an interesting phenomenon that goes on very often in the last propulsion stage that put these satellites into orbit. You get the thing spinning and then you light the last propulsion stage. If the thrust of the last propulsion stage isn't lined up perfectly with the axis of rotation (it never would be perfectly), you set up a kind of coning effect there and once you set that up an interesting thing happens. If there are wires or anything that can vibrate inside, this coning puts acceleration forces on them and the vibration might extract energy. If it does, you lose energy through something like this vibration of components, but since angular momentum must be consumed, I think you will find that the satellite tries to seek rotation about its maximum inertia axis so I would conclude that one might expect tumbling about the maximum inertia axis.

Dr. Roberson:

I would just like to say that you probably do get this effect because, as some studies of the electromagnetic dissipation for spinning satellites have shown, you very easily extract enough energy to have this phenomenon occur.

Mr. Farrior:

In the case of the Explorer I and Explorer III shortly after the last booster burned out, this rotation about the longitudinal axis was changed to rotation about its axis of maximum inertia.

Question:

What insight do you now possess into exotic systems for control of space vehicles?

Mr. Stearns:

I have a very cloudy crystal ball. I haven't been giving it very good maintenance lately. We have done some thinking at Lockheed and I have done some thinking individually on the subject. I think perhaps I should put Dr. Draper on the hook here to clarify what I say

when I'm all through, because his laboratory has put out a very interesting paper recently at Denver on some advanced vehicles and the navigation and control systems which might come from them. We have done some thinking about such exotic things as advanced interplanetary navigation problems and, for my own thinking, the thought at the present is that these will become practical as long-term, sustained-propulsion systems become available, and we are able to get away from this minimum-energy type of trajectory that takes years and years to get from one place to another. For example, if we were to take a minimum-energy trajectory from here to Venus, it would take us something like 140 days to make the trip and we would have to stay there in the neighborhood of 100 days before we could return because we would have to have the proper relative positions of Earth and Venus both at the outset of the journey and at the outset of the return journey. The whole trip would take something like 400 earth days. This seems to be a rather unsatisfactory arrangement when, with solar rockets or plasma jobs you might expect to see the trip from here to Venus take 15 days with no requirements on the initiation time. You can see with this wide dispersion in time due to the minimum energy or just-kick-it-off-and-let-it-drift type of trajectory, as compared to the constant low-thrust type of trajectory, there is a lot to be gained. This is, I guess, the difference between the row boat age and the jet age of interplanetary travel. We feel this is a very essential element and perhaps adding fuel to decrease the time of the journey may be worth more than adding shielding and great quantities of survival gear and food so that the people on the trip can withstand the journey.

The question of navigation of this thing may be one of the problems we would be concerned with. I find that this navigation problem in interplanetary space is somewhat similar to and simultaneously somewhat different from the one on earth. On earth we like to use gravity as a direction to which to measure our star sight, but out in interplanetary space we don't have this gravity vector. We don't have any horizontal we can use, so then we'd have to use a star sight on the sun itself. Another thing we do on earth, after having used the horizon or the gravity vector as our reference, is assume that the elevation of the star represents our distance from some position that we can learn from the almanac. This is because in terrestial navigation we are constrained very nearly to a sphere of a certain radius from the center of the earth. In interplanetary travel, in which this will not be the case, we will have to use some other way of determining our position. Star sights from within our solar system don't have parallax and they represent then, a rather convenient method for fixing position. Solar system triangulation then, using two planets (probably the one you left and the one you are coming to) and the sun, appears to me to be the logical way of fixing positions. And, from that, you can compute your future headings and course. Does this answer your question or have I gone on long enough? I'm sure I have some more comments from the panel here.

Dr. Roberson:

I agree with Ed Stearns that this is probably a good way of fixing positions so he is not all alone. However, we are working on ways to try to avoid ever knowing your position. I think going back to the original question about exotic ways of doing things, Ed has already made the point properly and very well that exotic advances are likely to occur primarily in the field of propulsion. I think that in control problems, the solutions are not necessarily exotic because I think that many of the techniques that we are using today (when pushed in the direction that they are now going—e.g., microminiaturization) will probably be adequate for most space guidance and control problems. Now people are talking, in a few cases, about new exotic components such as nuclear spin gyros, things of this sort, but I think that the demonstration that these can be competitive with the kinds of spinning wheels that Dr. Ettenberh has discussed is yet to be made.

Question:

What kind of accuracies are you shooting for in attitude control?

Dr. Roberson:

I am not building any attitude control systems, but I think that I can say this: that the attitude control becomes an extremely difficult one if you start to ask for attitude accuracies much less than a degree.

Mr. Stearns:

The kind of attitude you are shooting for will depend a lot on your mission. If we are on an astronomical mission and we want to point a one-minute field telescope out to some astronomical object or outer space direction, we would have a very critical control of attitude. If on the other hand, we had a two-degree beamwidth antenna which we wanted to point to the ground at some kind of omni-directional receiving antenna, there would be a considerably more limited control requirement. Similarly, if we are trying to collect meteoritic particles with a hole, 10 degrees might be sufficient. Thus, the tolerance requirement is very strongly mission-oriented.

Mr. Farrior:

This dumbbell or gravitational dipole which determines the direction of the gravitational vector lines itself with the earth's radius vector and establishes a certain degree of attitude control, but this dumbbell can rotate about its longitudinal axis. This is a degree of freedom that is still left. However, a gyroscope worked in the sense of a north-seeking gyroscope can determine the direction which is perpendicular to the plane of the orbit of the satellite and will correct that ambiguity.

Dr. Draper:

Being something of a mechanic myself, I would like to suggest that however you may choose to establish a geometrical reference space—whether you do it by vibrating tuning forks or rotating molecules or electrons or whatever—the basic problem is still one of geometry. As Dr. Roberson has mentioned, if you're going to use

geometry, you must have some kind of a reference. Any angle has three elements. The first is the place, that is, the reference, from which you start measuring the angle; the second is the geometrical entity that you locate; and the third is the angle between the reference and the located entity. For reference purposes in space, it seems to me that a normal co-ordinate system is indeed the celestial sphere. Now you can establish a physical reference–co-ordinate system by gyros and servo drives that are available today. The inertial-reference package, which is an actual physical member, can be set up so that you have celestial-sphere co-ordinates inside your equipment. You can use the direction of the polar axis of the earth and some celestial-sphere direction at right angles, to establish relationships with inertial space that may be continuously made available by optical trackers. After you once get started, the logical thing is to use lines of sight to known bodies. The advanced vehicle described in the paper to which Ed. Stearns referred did, in fact, use a minimum amount of gyroscopic equipment. It is based on a combination of gyroscopic equipment and automatic line-of-sight trackers for celestial bodies.

Question:

What times are involved in interplanetary travel?

Dr. Levitt:

I don't precisely know what the answer to this is. We can get up to something up to 16 thousand days for a trip to say Pluto, the outer planet, with a minimum-energy orbit, the most economical orbit. For solar sailing we are restricted because the inverse square law comes into operation; perhaps by the time you get out to Mars, the solar radiation will be so attenuated that it will be physically impossible to make a sail thin enough to be effective. Beyond this point it will be necessary to use ion rockets and nuclear powered rockets. With these propulsion systems I think you can go to the outermost planets in slightly less than a year.

Question:

Would Dr. Levitt simplify his comments on the gravitational field associated with a rotating body?

Dr. Levitt:

The general theory of relativity indicates that if you rotate a central mass, you must have an effect on the satellite moving around it. There isn't very much more I can tell you about it. I know the order of magnitude. In a satellite at a normal distance of say 4 or 5 hundred miles above the surface of the earth, you can get an advance in the line of apsides of 50 seconds of arc per century. Incidentally, this is the first time I have seen this in print. This was the work of a Russian, Ginzberg, back in 1956. Just to check this out, I asked Dr. F. W. G. Swan, director of the Boarol Foundation of the Franklin Institute, who is an authority on this, and we talked for a matter of a day and a half about this. He is convinced this is a real effect.

Question:

Is the gravity field propagated instantly?

Dr. Levitt:

I don't know.

Question:

Would Dr. Levitt comment on the accuracy of orbit calculations?

Dr. Levitt:

Well, I think that right now we lack mathematical tools. I had a long talk with Paul Herget, who is responsible for the computations for the Vanguard orbits, and we very definitely lack the mathematical tools now to compute the orbits precisely, taking into account all the perturbations. In a few years, the people in celestial mechanics (these are not necessarily astronomers) will improve the procedures. Some engineers in the missile industry, for example, are doing some significant work in orbit computations and are getting away from conventional methods. Astronomers have been taught and teach procedures that go back 160 years. The new methods developed by the people in the missile field today may be the ones used to resolve the n-body problem.

Mr. Stearns:

I would like to point out that one of the reasons that we are interested in the n-body problem so much nowadays—we manufacturing astronomers (sometimes known as astronauts)—is that we want to know exactly what kind of a trajectory we are going to get as we wend our way through the sun's gravitational field from the vicinity of one planet to the vicinity of another planet. One way in which this thing is being tackled, and I'm sure it is being tackled in several different places, is to solve the problem not by computing the thing as a minimum-energy trajectory or Hohmann orbit, as it is sometimes called, but rather to tackle the problem as one of navigation and control in which you actually solve the interception problem rather than the one which you are really worried about—the n-body problem.

Question:

If we put a precise clock on a satellite and compare it to one on earth, would we learn something of relativity?

Dr. Levitt:

Yes, I think Dr. S. Fred Singer had a paper on that within the past few years. If you have an object moving at five miles per second and you put that speed into the expression $1/\sqrt{1 - v^2/c^2}$, you will get a time dilation of the order of a second a century. This is a hundredth of a second in a year, but you must remember you can chop a second up into at least a hundred million parts, perhaps a billion by this time, and so in a relatively short time with the aid of a very accurate clock (a crystal or a molecular device of some sort) you can in a very short period of time correlate these two clocks to see whether or not this relativity effect is present. If it is, of course, it is another proof for this theory. We may not need any more proof, but this is another one.

Steam Station Auxiliary Transfer Arrangements

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THE PURPOSE of this article is to suggest methods of transfer, utilizing a metal-clad breaker with a 5-cycle closing time, which practically eliminate transfer problems.

The breaker operating mechanism is a stored-energy mechanism in which energy from a small operating motor is stored in powerful springs.

The results of a computer study, made on the auxiliary system of a 175 megawatt (mw) unit to help determine the advantages of using the fast-closing breaker, are shown in Figs. 1 and 2. Throughout the article, it is assumed that the normal and emergency sources of power to the auxiliary system are essentially in phase. Fig. 1 shows the change in angle of the bus residual voltage following tripping of the main source with the main unit at full load for purposes of motor loading. The smaller the angular difference, the less the shock to motor windings because of inrush currents and the faster the recovery of the motors to normal operating speed. Fig. 2 shows the recovery voltage on the auxiliary bus for several values of throwover dead time. Note that at 3- and 6-cycles dead time, the voltage dip is less than 10 per cent.

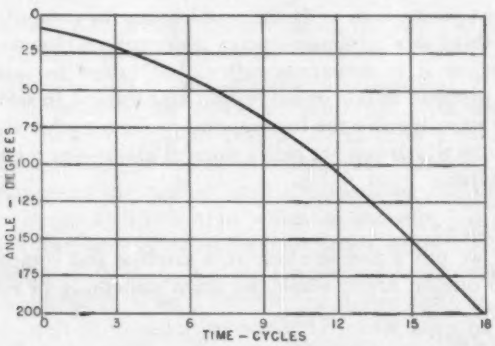

Fig. 1. Decay of bus residual voltage angle during transfer.

The computer study indicates that when 5-cycle breakers are used as source breakers, the following methods of transfer should be considered:

1. Routine Transfer
   a. Continuous circuit
   b. Giving the signal to trip one source breaker and close the second source breaker at the same time (called "3-cycle transfer")
2. Emergency Transfer
   a. Three-cycle transfer as in b under Routine Transfer.
   b. Delay closing of the incoming source breaker until a contact on the tripping breaker indicates that it has tripped (called "6-cycle transfer")

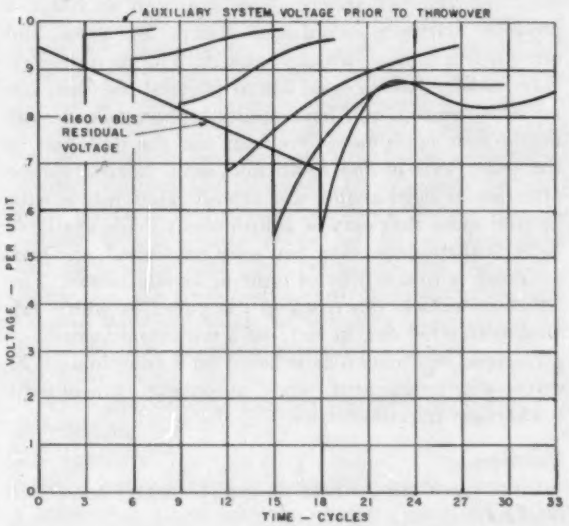

Fig. 2. Decay and recovery of bus voltage for various times of transfer.

As a conservative approach, 6-cycle transfer is listed only under Emergency Transfer inasmuch as the angular difference is getting large enough so that the net voltage applied to the motors might be greater than 100 per cent for some particular systems. However, since routine throwover occurs under controlled operating conditions, and since the rate of change of angle depends on motor loadings, it appears reasonable that motor loads can be so fixed that 6-cycle transfer can be also used for Routine Transfer.

The following conclusions have been reached:

1. The methods of bus throwover outlined, utilizing the breaker with 5-cycle closing time, practically eliminate problems of voltage dip, excessive shock to motors on interrupted-circuit transfers, and boiler instability caused by long motor recovery times.

2. For those who prefer to use open-circuit transfer at all times, a method is available which permits this type of operation even on large generating units without incurring a large cost penalty.

Digest of paper 58-93, "Switchgear with Stored Energy Mechanism Applied to Steam Station Auxiliary Transfer Arrangements," recommended by the AIEE Power Generation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting. New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Power Apparatus and Systems*, June, 1958.

P. G. Brown, D. G. Lewis, and J. J. Heagerty are with the General Electric Company, Schenectady, N. Y.; E. M. Smith is with the General Electric Company, Philadelphia, Pa.

The Institute and Electrical Insulation

L. F. HICKERNELL
PRESIDENT AIEE

Since 1884, Institute meetings have included paper presentations on the state of the art of insulation. President Hickernell gives quotations from some of these to emphasize the tremendous progress to date, and the continued increase in technical activity throughout the entire field.

THE DISCOVERY of electrical insulation generally is credited by historians to Stephen Gray (1696-1736), an English electrician who was the first to divide substances into conductors of electricity and nonconductors, or insulators, as they could or could not be electrified by friction. In a series of experiments from June 30 to July 14, 1729, he demonstrated on July 3rd that silk thread was an insulator, and that packthread and iron and brass wire conductors. He contributed very complete descriptions of his experiments, in the form of a daily log,[1] to the *Philosophical Transactions* of the Royal Society of London, including his difficulties in constructing and insulating a 650-foot transmission line. The experiments were started between 10 and 11 in the morning. In the evening:

> ". . . before 8 the attraction ceased: But whether this was caused by the dew falling, or by my being very hot, we could not positively say, but I rather impute it to the latter." (p. 31)

Even had he not made an historical discovery, Gray's description of his apparatus, procedures, and results (including failures) would serve as a model research report today. For example, he describes his tube for generating friction electricity as follows:

> "Its length is 3 feet 5 inches, and near 1 inch 2 tenths in diameter: I give the mean dimensions, the tube being larger at each end than in the middle, the bore about 1 inch. To each end I fitted a cork, to keep the dust out when the tube was not in use."

INITIAL DEVELOPMENTS

IN 1823, William Sturgeon (1783-1850), English electrician and inventor, devised the first electromagnet. He bent iron wire into a horseshoe shape, insulated it with *varnish*, and wrapped it with bare wire in an open helix.

On October 10, 1827, Joseph Henry (1797-1878), American physicist, announced his invention of a practical electromagnet. In his own words: ". . . the idea occurred to me . . . of *insulating* the conducting wire itself, instead of the rod to be magnetised, and by covering the whole surface of the iron with a series of coils in close contact. This was effected by insulating a long wire with a *silk* thread." His next step was to wind the coils in several layers, insulating each layer with silk ribbon.

Accordingly, the subject of insulated magnet wire is at least 131 years old.

AIEE CONTRIBUTIONS

ON OCTOBER 7-8, 1884, the first meeting for the reading and discussion of papers was held by the AIEE at Philadelphia, Pa., during the International Electrical Exhibition. Eleven papers were presented and discussed, one of which was entitled "Underground Wires," by W. M. Callender.[2] It contains this interesting summary of the state of the art of insulation for underground conductors 75 years ago:

Essentially complete text of an address presented at the 1st National Conference on Application of Electrical Insulation, cosponsored by AIEE and the National Electrical Manufacturers Association, Cleveland, Ohio, Sept. 3-5, 1958.

L. F. Hickernell is with the Anaconda Wire and Cable Company, Hastings on Hudson, N. Y.

"The only 3 insulating materials that need be considered are gutta percha, rubber and its compounds, and bitite or vulcanized bitumen–paraffine and the numerous cotton coverings, although very useful in their own place, are no good for underground, they will neither stand the dampness, nor in fact can they ever be considered as 'insulating' a wire."

That extravagance of claims for various kinds of insulating materials is not a modern development is evidenced by a paper on "Underground Electrical Systems," by S. F. Shelbourne,[3] presented on May 19, 1886, in which he states:

"Of insulation but little need be said, because the subject is hackneyed of words. The whole list is good–better–best, and every new man can give us the best, because, he says, God has made him the Mohamet of a new revelation." (p. 40)

The first AIEE paper on insulation, per se, was presented at Chicago on June 8, 1892, entitled, "Oil vs Air as an Insulating Medium," by J. B. Williams, M.D.[4] His evaluation was limited to insulation resistance as measured by a special quadrant electrometer, the specimen being charged by a 6-inch spark coil. The oils tested were rosin (London), paraffin, linseed, cottonseed, and castor. When continuous high-tension currents alone are concerned, the author concluded:

"1. That air, even when it has a humidity of 80%, is infinitely superior to oil for insulating conductors carrying such currents.
"2. That pure paraffin is far superior to oil, both for insulating conductors and for preventing the escape of the current across the surface of glass.
"3. That air having a humidity of 80% is superior to paraffin as an insulating medium."

In postponing the discussion to a meeting at New York on November 15th when Dr. Williams demonstrated his tests, President F. J. Sprague said, "I am sure that some of the conclusions . . . are entirely contrary to the generally accepted belief . . ."

At the next meeting, December 21, 1892, a very interesting paper was presented entitled "Micanite, and Its Application to Armature Insulation," by E. P. Thompson, for C. W. Jefferson and A. S. Dyer.[5] Among the 10 discussers was Charles P. Steinmetz, who presented a long discussion which included the following observation:

"We have listened tonight and at the last meeting (to Dr. Williams) to some very interesting statements regarding that quality which is called insulation resistance . . . My experience has led me to an opinion somewhat different from that generally expressed. *I believe very little in insulation resistance* . . . (p. 814)

Two months later, on February 21, 1893, Steinmetz presented his classic paper[6] entitled, "Note on the Disruptive Strength of Dielectrics."

CLASSIFICATION BY TEMPERATURE

On February 26, 1913, Steinmetz and Benjamin Garver Lamme presented their historic paper[7] on "Temperature and Electrical Insulation," which grouped then-known insulating materials into Classes A, B, and C, according to their heat-resisting properties. Where comparatively long life is a requirement, they recommended "maximum ultimate temperature permissible in the insulation" of:

100 C for Class A insulations
125 C for Class B insulations

The first appearance of the designations, "Class A, B and C" in the "Standardization Rules" was in the edition which took effect July 1, 1915. The maximum temperature for Class A was increased to 105 C.

THE INSTITUTE'S POSITION

Thus, it is evident that the Institute has been concerned with electrical insulation in all its aspects; not only in dielectric theory but also in practical application. Just as the subject was discussed at AIEE's first technical meeting 75 years ago, it has been a recurring topic in *Transactions* down through the years. Numerous papers have been presented at both General and District Meetings, of which at least 8 are held each year

However, the wealth of new insulating materials for use individually and in combination have indicated the desirability of a new forum for formal and informal exchange of ideas among all interests: producer, designer, user. AIEE is pleased to sponsor this gathering with NEMA, being well endowed by heritage and organization to accept the undertaking. Each year, AIEE holds 25 or more such Conferences on specific subjects.

Our modern committee structure is ready to do the spade work. The Institute is equipped to serve specialists in the whole range of electrical engineering topics. Vertically, we have the apparatus and equipment committees, such as rotating machinery, transformers, instrumentation, electronics, insulated conductors. Horizontally, there are the industry committees: petroleum, metal, mining, chemical.

As technical activity increases, expansion room is provided. The Instruments and Measurements Committee, for instance, was placed under the Science and Electronics Division when Divisional groupings of technical committees were put into effect in 1946. Ten years later, the Committee itself became a Division, with 7 Committees and 34 Subcommittees.

Publication facilities are available for all types of papers, Those of permanent value are published in the Bimonthlies and yearly *Transactions*. Papers of transitory interest may be preprinted for distribution at meetings to which they are presented. Proceedings of any given Conference may be published under one cover as a so-called "Special Publication."

Exhibits such as we have witnessed here at Cleve-

land are welcome adjuncts to our meetings whenever they are considered educational and desirable.

In conclusion, I would like to congratulate those responsible for this Conference. They include not only the chairmen, committeemen who made the arrangements, and the authors, but also the group of men who sparked the meeting last Fall. They let it be known that they were not satisfied with then-current efforts to evaluate, discuss, and disseminate information about electrical insulating materials. They wanted something done, and were willing to do it themselves, if need be. So effectively did they ignite the spark that this Conference is being held 6 months ahead of time The first tentative scheduling was for Spring 1959. Here is an evidence of the American spirit at work. As long as this spirit prevails, the continued phenomenal growth of our electrical industry is assured.

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Role of AIEE in Electrical Insulation

L. J. BERBERICH
FELLOW AIEE

A brief exposition of the activities and progress of the AIEE in the electrical insulation field.

THE AMERICAN Institute of Electrical Engineers (AIEE) is an organization of over 50,000 individual engineers with 12 districts and 113 local sections ranging over the United States, Canada, and Mexico. It was founded in 1884 with the object of advancing "the theory and the practice of electrical engineering and of the allied arts and sciences and the maintenance of a high professional standing among its members." While electrical insulation may not be considered a strictly electrical engineering function it certainly can be classed as an "allied art and science." Hence, for this and the reason that electrical insulation is required in all electrical equipment, the AIEE has devoted considerable attention to this field from its very beginning. It is the purpose of this exposition to review briefly the insulation activities in the AIEE and to show how they lead to advancements in this important field.

ORGANIZATIONAL STRUCTURE

THE AIEE is operated by a Board of Directors and its affairs are administered by the following five departments: (1) Administration, (2) Admission and Advancement, (3) Professional Development and Recognition, (4) Publications, and (5) Technical Operations. Only the last named will be discussed further, because it is this department that concerns itself with the technical activities of the Institute. Electrical insulation certainly falls within the last-named category. The Technical Operation Department is, in turn, divided into six divisions as follows: (1) Communications, (2) General Applications, (3) Industry, (4) Instrumentation, (5) Power, and (6) Science and Electronics. Each of these Divisions is further divided into a number of technical committees. Most of the electrical insulation activities of the AIEE were carried out for many years in the Power Division, largely because this is the area where insulation found the most important applications. Hence, until about 1952 most of the insulation activities were administered by working groups or subcommittees of insulation attached to three Power Division apparatus committees. These are the Rotating Machinery Committee, the Transformer Committee and the Insulated Conductors Committee.

Insulation standards, however, created a problem in some cases inasmuch as some of them applied to more than one type of equipment. An example of this is the insulation temperature standard covered by AIEE No. 1. This standard was originally developed by the Rotating Machinery Committee even though it presumably also applied to transformers. This situation was

Essentially full text of a paper presented at the First National Conference of Electrical Insulation, Cleveland, Sept. 3-5, 1958.

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later partially corrected by the creation of a special Standards Co-ordinating Committee which undertook several revisions of AIEE No. 1 in the last 10 years. This latter committee represented all of the apparatus interests and was attached to the Standards Committee which finally has to approve all new and revised standards of the AIEE. The Standards Committee is one of the four general committees also attached to the Technical Operations Department, but outside of the six divisions mentioned earlier. This somewhat complex method of treating general insulation standards still is in operation but will undoubtedly be improved in the future as the field of insulation gradually receives more and more attention by the AIEE.

A number of years ago, the measurements and instrumentation aspects of the field began to assume increasing importance. Since no committee existed until very recently which could treat the subject of insulation broadly, the Instrumentation Division fortunately became active in this area. As a result, there is now a Subcommittee on Measurements on Dielectrics and a Subcommittee on Techniques for Dielectric Tests, both attached to the Special Instruments and Auxiliary Committee. Other aspects of this phase of the field are being treated capably by the ASTM Committee D-9 on Insulating Materials.

Until the last few years, there was no place in the Institute organization for the treatment of the more basic aspects of the field. Hence, in 1952, a Subcommittee on Dielectrics was formed within the Basic Sciences Committee of Science and Electronics Division. The objective of this subcommittee was to treat the theoretical or more basic aspects of the field and to bring to attention of the AIEE membership new developments in this area from the fields of physics and chemistry. Once this subcommittee was established, it grew rapidly. Its activities expanded into various aspects of the insulating materials area and even general applications, largely because there was no other place in the Institute organization for them. As a result of this growth and increasing appreciation of this field within the AIEE, the Subcommittee on Dielectrics became a full, independent committee of the Science and Electronics Division on August 1, 1955.

This Committee started as the "Committee on Dielectrics" but its name has recently been changed to "Electrical Insulation Committee" to bring its name more into line with its broad functions. The committee is now fully organized with eight subcommittees and its functions will be discussed in some detail in the next section. The writer has had the privilege of serving as the first chairman of the Committee after having served as chairman of its predecessor subcommittee since its organization. It has been a truly stimulating experience to have been associated with this development but it should be emphasized that the record that the Committee has made is largely attributable to the support, interest, and hard work contributed by the officers and members of the main committee and its various subcommittees and working groups. The establishment of a full Electrical Insulation Committee within the AIEE represents a true milestone of progress in this area. Not only will the AIEE and insulation field benefit, but also it should serve to stimulate the development of new materials and, in this way, bring about advancements in electrical equipment generally.

OBJECTIVES OF THE COMMITTEE

THE PRINCIPAL OBJECTIVES of the Electrical Insulation Committee is to bring to the Institute membership new developments in the field of electrical insulation and associated dielectric phenomena ranging from theory to general application. This includes the following:

1. The sponsorship, jointly with other associations, of the National Conference on Application of Electrical Insulation.
2. The promotion of symposia on all aspects of the field of electrical insulation, ranging from theory to general applications at national and district meetings of the Institute, for the purpose of serving design and development engineers who apply this information to practice.
3. The treatment of the various phases of field of electrical insulation such as gases, liquids and solids, and prepare standards in these areas where desirable.
4. The study of the mechanism of deterioration of electrical insulating materials, particularly as caused by heat, corona, and radiations of various types.
5. The development and standardization of test procedures for the thermal evaluation of insulating materials and simple combinations of these materials, but not including systems of materials as used in specific apparatus or equipment.
6. The co-ordination of the various activities in the field of electrical insulation in the Institute and maintain effective liaision with other associations dealing with electrical insulation such as the American Society for Testing Materials, the National Research Council Conference on Electrical Insulation and the National Electrical Manufacturer's Association (NEMA).
7. To promote the dissemination of information on electrical insulation through the stimulation of publication of symposia, special reports, books, etc. by the Institute, trade journals, book publishers, etc.

To carry out these objectives, the present Committee organization, in addition to the main committee of about 50 members, consists of the following eight subcommittees:

1. *Administrative Subcommittee* which administers those affairs of the Committee that do not require formal action by whole committee membership.
2. Solid Insulation Subcommittee.
3. Liquid Insulation Subcommittee.
4. Gaseous Insulation Subcommittee.
5. Effects of Corona on Insulation Subcommittee.
6. Effects of Radiation on Insulation Subcommittee.
7. Thermal Evaluation of Insulating Materials Subcommittee.
8. West Coast Subcommittee which represents the main

committee in a broad manner in the West Coast area.

While space does not permit going into much detail, it should be pointed out that some of these subcommittees have a number of working groups for carrying out various projects. For example, the Thermal Evaluation of Insulating Materials Subcommittee, has 11 working groups, each working on the development of test procedures for the thermal evaluation of a particular class of material. It is through the development of these test procedures that the Committee is playing an important role in implementing the new insulation temperature standards as set forth in the 1957 edition of AIEE No. 1. One such test procedure for the thermal evaluation of enamelled magnet wire has already been published as AIEE No. 57. It is expected that others will soon be reaching the stage where they can be published. The listing of the subcommittees and this brief description should serve to give some indication of the extent of the activities of the Committee.

In view of the prior existence of the insulation subcommittees attached to the various apparatus committees in the Power Division, the Electrical Insulation Committee does not treat systems of insulation which apply only to a single type of apparatus, such as rotating machinery, or transformers, or cables. For example, in the area of AIEE No. 1, the subcommittees on insulation attached to the Rotating Machinery Committee and to the Transformer Committee independently have developed test procedures for determining the thermal rating of systems of insulation as they are used in their respective equipments. Several such test procedures have already been issued, namely AIEE Nos. 510 and 511 on rotating machinery insulation systems and AIEE No. 65 on dry-type transformer insulation systems. Other apparatus insulating system test procedures are under development. The activities of these subcommittees and those of Electrical Insulation Committee in the area of insulation temperature standards are being co-ordinated by the Standards Co-ordinating Committee No. 4, which is attached to the Standards Committee as previously mentioned.

Perhaps the most important single activity of the Electrical Insulation Committee is the sponsorship, jointly with NEMA, of the National Conference on Application of Electrical Insulation. The general chairman of this Conference is appointed by the chairman of the Committee. The Conference chairman, in turn, with help from AIEE headquarters and the committee, develops the Conference organization. A registration fee is usually imposed of such magnitude as to make the Conference self-supporting. This year of 1958 marks the beginning of this activity and it is expected the Conference will be an annual affair. The presentation of almost 140 technical papers, the interesting open forum discussion, and the high quality of the technical exhibits of insulating materials have made the first conference in this area to be sponsored by AIEE–NEMA an outstanding success. Its continuance on an annual basis appears to be assured.

SUMMARY

THE INSULATION ACTIVITIES in the AIEE are quite extensive and range from the treatment of the basic aspects of the field, to standardization, to insulation measurements, and to practical applications of insulation to electrical equipment. While the organization within the Institute for treating this wide-range field is somewhat complex, it has been considerably improved in recent years through the formation of the Electrical Insulation Committee in 1955. This Committee, which is in the Science and Electronics Division of the Technical Operations Department, is receiving increasing responsibility for treating the electrical insulation field broadly. One of its more recent responsibilities is the sponsorship, jointly with NEMA, of the National Conference on Application of Electrical Insulation. The various apparatus committees of the Power Division, however, still retain the prerogative of treating insulation systems of materials as they apply to their specific equipments. The Instrumentation Division also becomes involved in these activities through the measurements and instrumentation aspects of this field.

Thus, it may be said that the rather extensive insulation activities within the Institute involve three of the six divisions of the Technical Operations Department, and these are the Power Division, the Science and Electronics Division, and the Instrumentation Division. When a standard is being developed, even more of the AIEE organization becomes involved. The standard may originate and be developed in one or more committees of a single division. In some cases, it may also be a co-operative venture and involve several divisions. All standards of the AIEE have to be approved by the Standards Committee, which is a separate general committee of the Technical Operations Department. When several committees or divisions are involved, a special standards co-ordinating committee representing all of the various interests is often formed. This committee then develops the standard and sends it to the Standards Committee for approval. When the standard is approved, it is issued as an AIEE standard. The standard, if desired, may then be submitted to the appropriate committee of the American Standards Association for consideration as an American (ASA) standard. If the standard is to be considered in the international area, it may be submitted to the appropriate committee of the International Electrotechnical Commission, which may issue it as a world (IEC) standard.

There is no question that the electrical insulation activities of the AIEE have been valuable and effective in stimulating advances in the electrical area. It is possible that these activities could be made even more effective through a simplification of organization. The establishment of the Committee on Electrical Insulation in 1955 represents a milestone of progress in this respect and perhaps consideration should be given to concentrating more of the electrical insulation activities of the AIEE in this Committee.

Artificial Cooling of Livestock in Hot Climates

C. F. KELLY T. E. BOND N. R. ITTNER

Fig. 1. Direct expansion coils and controls for cooling beef cattle drinking water to 65 F.

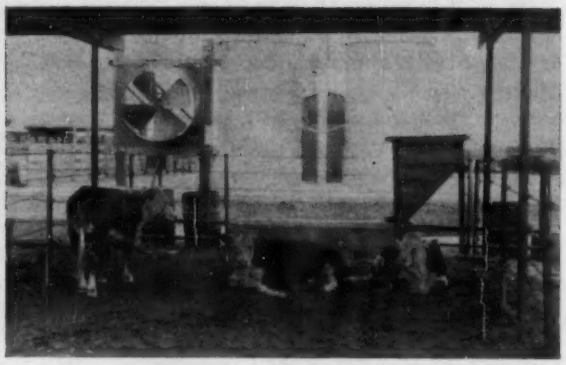

Fig. 2. Ventilating fans in experimental pens at Imperial Valley Field Station, University of California, El Centro, Calif.

ADULT LIVESTOCK are considered to be depressed by ambient temperatures above 75 F—the range of optimum temperatures for laying hens is 55 to 65 F, for dairy cows 50 to 60, and for swine 65 to 75.

A series of co-operative studies between the University of California and the U. S. Department of Agriculture were initiated at the University's Imperial Valley Field Station in 1946, the objectives being to measure the effects of hot weather upon livestock, and to develop means of protecting the animals from hot environments. The Imperial Valley is very well suited to hot weather studies of this type, the mean monthly temperature being above 75 F for about 6 months of the year, exceeds 85 for nearly 4 months, and reaches 90 F for 2 months.

The studies discussed in this article have to do with the use of electric power to cool the animals. The methods used were: cooling the drinking water to cool the animal internally; increasing air motion or decreasing ambient air temperature to increase convection cooling; and providing a cooled slab for the animals to lie on in order to increase the rate of heat loss by conduction.

Drinking water was cooled from the normal 80 to 90 F down to 60, 65, or 70 F in tests with Hereford beef cattle conducted over a 6-year period. Both refrigeration, by direct expansion coils immersed in the 'drinkers," and evaporation cooling towers, were used to reduce the water temperature. Salt in excess added to the pelleted feed was fed one year to increase water intake in an effort to increase cooling effect. The following general conclusions can be drawn from the drinking water experiments:

1. Average daily gains per animal were increased by about 0.30 pounds.

2. Under the conditions of the test, there was little difference in results between water temperatures of 60 and 70 F.

3. Salt in excess added to the feed increased consumption of cold water but did not increase daily weight gains.

4. Water consumption decreased slightly when the water was cooled.

5. Cooling by evaporation did not lower water temperature enough to produce increased gains.

The effect of fans upon weight gains of beef animals in wood corrals was startling. In 1955 and 1956 gains were increased 44% and 22%, respectively, with 30% and 19% less feed per 100 pounds gain. Low-speed ventilation fans, 42 or 44 inches in diameter and rated at about 17,000 cubic feet per minute free air delivery, were used in all the tests. Results with fans were not nearly so marked when the animals were kept in wire or cable corrals where natural breezes could flow.

Fattening swine were housed two years (1956 and 1957) over a shaded concrete slab cooled to 65 F by refrigerated water. Control pigs were kept in an identical pen, without a cooled slab but they had access to a concrete water wallow. While the cooled slab pigs were much more comfortable, as evidenced by much lower respiration rates and body temperatures, the effect on weight gains was not clear cut—in 1956, daily gains were slightly less; in 1957, somewhat more. However, efficiency of use of feed was in favor of the cooled slab both years.

Digest of paper 58-1007, recommended by the AIEE Domestic and Commercial Applications Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Pacific General Meeting, Sacramento, Calif., Aug. 19-22, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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Power for Mysore

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The Sharavathi Valley Project has been established to meet the ever-increasing power requirements of the State of Mysore in southwestern India. The project's dam, water conductor system, and surface station, as well as its transmission line, receiving station, and electric equipment, are described.

MYSORE, INDIA, has been a pioneer state in the East in the field of electric power development. The first hydroelectric station at Sivasamudram was started as early as 1898 and placed in service in 1902, two years after the well-known hydroelectric installation was commissioned at Niagara Falls, N. Y. In fact, the project at Sivasamudram, which was executed in close collaboration with the General Electric Company, has many points of similarity in design with the first station on the Niagara. At that time, Mysore had the longest transmission line in the world, 88 miles long, supplying power to Kolar Gold Fields.

Mysore now has three major hydroelectric stations, with the following firm capacities:

Sivasamudram	22,500 kw
Shimsha	17,200 kw
Mahatma Gandhi Hydroelectric Station	102,000 kw

There are also about 1,800 miles of high-tension lines and 48 receiving stations of 33 kv and above.

NECESSITY FOR THE PROJECT

THE AVAILABILITY of the cheap hydroelectric power, in addition to the climate and other conditions favorable to the growth of industry, has led to the rapid industrialization of this part of the country, with the result that the utilization of power has far outstripped the generation. The present load factor of the system is as high as 78%, and staggering and shedding of load has to be resorted to in order to keep the peak load within the system capacity. To meet this shortage of power, the major scheme taken up for execution in the Second Five Year Plan of the Government of India is the Sharavathi Valley Project. The project, which was under investigation since 1902, was decided upon because it is the most economical one that can meet the load demands of the area for some time to come.

The project will utilize all the water that is available from the Sharavathi River, which has a total length of 82 miles from its source at Ambuthirtha in Shimoga District to the Arabian Sea. The entire catchment basin lies in a very steep and thickly wooded area and, in some parts, the annual rainfall is as much as 320 inches per annum. About 70% of this precipitation occurs between the months of July and August. Hence, the percentage of runoff from the catchment is very high, and the flow in the river varies between 5 cfs (cubic feet per second) in summer to about 200,000 cfs during monsoons.

Actual records of rainfall and runoff for the river are available for the past 58 years. This information is helpful in appraising the power potential of the scheme. It has been estimated that the total potential of this stream is of the order of 936 mw at 60% load factor.

Generation of power will be accomplished by harnessing the river in various stages, depending upon the requirements of power in the State. It is proposed to generate power immediately to the extent of 178.2 mw in the first stage, which is estimated to cost about 23 crores of rupees or $46 million.

The complete investigation, design, and construction of the project has been undertaken by the local engineers.

THE LINGANMAKKI DAM

BECAUSE THE RIVER'S DISCHARGE varies from about 5 cfs in summer to 200,000 cfs in the rainy season, sufficient storage is necessary to ensure a steady flow for the generation of power. This is provided by 178 billion cubic feet of storage at a dam which is proposed to be constructed in stages. This dam will be situated near a village called Linganmakki. The site is ideally suited for the construction of a high dam. In the final stage, the dam will be 205 feet high and 6,850 feet long at the top. The dam will be constructed of size stone masonry with surki mortar. Necessary inspection galleries, vents, etc., have been provided, and a roadway 18 feet wide will run along the top of the dam. Power to the extent of 45,000 kw is expected to be generated at the dam site station in the ultimate stage.

WATER CONDUCTOR SYSTEM

THE WATER CONDUCTOR SYSTEM from the main reservoir to the forebay consists of

1. An open-cut power channel 12,320 feet long to lead the water from the main reservoir to the entrance of the Malali tunnel, designed to carry 6,200 cfs with a velocity of 7.85 feet per second.
2. A 2,000-foot-long tunnel called the Malali tunnel, with a capacity of 6,200 cfs.
3. An open-cut channel 3,850 feet long from the exit of the Malali tunnel to the Talkalale reservoir.

A special article recommended by the Hydroelectric Systems Subcommittee of the AIEE Power Generation Committee.

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4. A 175-foot dam across the Talkalale stream to form a reservoir into which the water from the Malali tunnel is dropped and is picked up again at Vodenbailu.

5. A 30-foot-diameter pressure tunnel, called the Vodenbailu tunnel, with an approach cut designed to carry 8,700 cfs with a velocity of 12.3 feet per second.

6. A forebay, also serving as a surge tank, with 10 outlets, out of which two will be used in the first stage.

The complete power channel is proposed to be lined with concrete to prevent seepage losses and to facilitate continuous operation. The tunnels will also be lined with concrete. The water conductor system up to Talkalale balancing reservoir will be designed for 6,200 cfs, and the portion from the reservoir to the forebay for 8,700 cfs. The capacity of the balancing reservoir will equalize the momentary variations in flow and also provide for sufficient storage for the diurnal fluctuations. The velocity of water in the open channel is assumed at 7.85 feet per second. The Vodenbailu tunnel, designed as a pressure tunnel, will open out into the forebay which serves as a surge tank.

SURFACE VS UNDERGROUND

THE ECONOMICS of a surface station as compared with an underground location were worked out in detail. The site conditions were found to be ideal for either a surface station or an underground location. The uniform slope for the laying of the penstock pipes, the wide flat area near the river for the location of the station and the switchyard, and the easy foundations pointed to a surface station. But the formation of the rocks were ideal for tunneling purposes and the savings in steel and cement, which are commodities in short supply in India, were points in favor of an underground location. The alternative designs were worked out in great detail and extensive rock core samples were obtained. Finally a decision was made in favor of a surface station.

SURGE TANK AND PENSTOCK

A SIMPLE SURGE TANK was designed to take care of complete rejection of full load by the power station. It will have 10 outlets for the 10 penstocks, only two of which will be used in the first stage, the remaining eight outlets being blanked out.

The whole length of 4,300 feet of penstock, the economical diameter of which was found to be 8 feet uniform, is divided into two sections. The first section—for a length of 1,300 feet from the forebay—is made of mild steel with thickness of plate varying from $\frac{5}{8}$ to $1\frac{3}{4}$ inches; and the second section of 3,000 feet of high-tensile steel with thickness varying from $1\frac{1}{16}$ to $1\frac{3}{4}$ inches. The ultimate tensile strength of mild and high-tensile steel have been assumed to be 60,000 and 100,000 psi, respectively. The weight of two penstocks to be installed in the first stage will be about 5,198 tons, out of which 2,080 tons are of mild steel and the remaining 3,118 tons of high-tensile steel. The penstocks, which will be of welded construction, will be designed with a factor of safety of 2 over the yield point. X-ray inspection of the welded joints and stress relieving for the pipes are also contemplated.

TURBINES AND GENERATORS

EACH PENSTOCK feeds an impulse turbine designed for an output of 124,000 brake hp at a gross head of 1,509 feet at the nozzle center. The number of jets to discharge 867 cfs through the turbine will be four or six, distributed equally around the periphery of the wheel. The speed of the turbine will be 250 or 300 rpm with the tail water discharged directly into the river. The decision to have a vertical impulse turbine was taken after considering in detail the relative advantages of an impulse over a reaction turbine and also the comparative merits of horizontal and vertical machines.

Each turbine will be coupled to a synchronous generator which will be of the indoor vertical-shaft salient-pole type, with direct-connected main and pilot exciters. The continuous output at rated speed and any voltage of normal $\pm 5\%$ is 89,100 kw at 0.9 power factor. Practically, this becomes the maximum possible output, considering the peripheral speed of a split-rotor alternator. The alternator voltage will be 11,000 or 15,000 volts. The excitation voltage is 250 volts and the generator has to work satisfactorily at any voltage, 5% above or below the normal voltage. Each turbine–generator unit will be complete with its own auxiliaries, such as thrust and guide bearings, bearing and cooling water pumps, compressed air, etc.

The short-circuit ratio of the alternator is specified as not less than 1.15 and line-charging capacity as at least 70,000 kva at zero leading power factor. A flywheel effect of over 18 million pound-feet^2 for 300 rpm and 26 million pound-feet^2 on 250 rpm, giving an inertia constant of about 3.78, will be incorporated in the rotor to give satisfactory speed governing and stability under line fault conditions. The generator is also capable of being run as a synchronous condenser of 50,000 kvar capacity.

TRANSFORMERS AND SWITCHGEAR

EACH GENERATOR will be directly connected to a 3-phase transformer of 99,000 kva or a bank of three single-phase units of 33,000 kva each through isolated-phase metal-enclosed bus ducts. These transformers, which step up the voltage to 220 kv, will be of the forced-oil water-cooled type and will be provided with off-load taps. The high-tension side will be solidly grounded, and so a basic insulation level of 900 kv instead of 1,050 kv has been specified for the bus.

Power from these two transformers is conveyed through the high-voltage high-speed breakers and isolating switches to the outdoor bus bars which, in turn, are connected through isolators and breakers to the 220-kv transmission line. A duplicate 220-kv bus is proposed for this station.

The low-voltage supply to the station and colony will be obtained by means of 2,000-kva transformers, which step down the generated voltage to 415 volts. These

transformers are fed from taps on the lead from each alternator to its associated transformer. An 800-ampere-hour battery at 250 volts dc is also provided for station service.

The circuit breakers will have a rupturing capacity of 5,000 mva and a full-load current rating of 1,200 amperes.

TRANSMISSION LINE

THE OVERHEAD TRANSMISSION LINE to Shimoga, where this station is interconnected with the existing grid, covers a total route length of approximately 65 miles. The conductors which were chosen, based upon corona and regulation considerations, are 795-MCM aluminum cable, steel reinforced (500-MCM copper equivalent), consisting of 26 strands of 0.1749-inch aluminum and seven strands of 0.136-inch steel. The ground wire used throughout the route is $\frac{7}{16}$-inch 7-strand galvanized wire, giving a protective angle of about 30 degrees. The 5,000-mva 1,200-ampere breakers at the Sharavathi end and at Shimoga will be of the high-speed 3-cycle type, provided with a reclosing device.

From Shimoga, another 220-kv line conveys power to Bangalore over a distance of 173 miles, where it is again connected to the existing grid.

Both the lines will be of double-circuit construction, each circuit in vertical formation with a ground wire disposed vertically above the phase conductor of each circuit. Only one circuit is being erected initially between Shimoga and Bangalore. A safety factor of 2.5 for power and ground wires and an overload factor of 1.5 for towers is assumed in the design. No ice loading is considered, and a wind pressure of 15 pounds per square foot on 1½ times the effective face of the tower and on ⅔ diameter of conductor is assumed. A minimum clearance of 23 feet from conductor to ground is taken. Although from theoretical considerations the economical span was found to be 1,320 feet, a ruling span of 1,050 feet was adopted from practical consideration. Insulation of the line is accomplished by means of 14 disks, each 10 by 5¾ inches, for suspension towers and 16 disks for dead-end towers.

RECEIVING STATIONS

ONE BANK of 100,000-kva transformers will connect the 220-kv line from Sharavathi to the 110-kv bus of the Mysore system at Shimoga. Since the ratio of transformation is two, it is proposed to use autotransformers with on-load taps. This transformer will be of the ON/OFB type. The insulation on the high-voltage side will be graded, and the insulation level of the neutral bushing will be 46 kv. The tertiary winding of this transformer will be for 11 kv and suitable for a synchronous condenser of capacity 30 mvar.

Similarly, at Bangalore, two banks of 67,500-kva transformers will interconnect the 220-kv line with the 66-kv system. These transformers will also be of the ON/OFB type and provided with on-load tap-changing gear. There will also be a tertiary winding for a condenser capacity of 30 mvar. One 30-mvar condenser is proposed to be installed in the first stage alone to improve the voltage level in this region and to limit the voltage rise during low-load periods.

CONCLUSION

THE ENTIRE PROJECT is scheduled to be commissioned in 1961-62 and global tenders are required for most of the major equipment. The transport limitations constitute a bottleneck on the meter gauge section, where permissible dimensions and weights are limited. Because these limitations proved to be a great handicap in the movement of heavy machinery, a hydrographic survey of the river was conducted to determine whether movement of equipment on water would be feasible. It was found that the materials from the ocean liners could be transferred to shallow barges, which will be required to sail in high seas and then up the river for a distance of 18 miles. By this method, it is possible to transport packages weighing up to 100 tons. At Gersoppa, the barges will transfer the packages to a suitable road vehicle for transportation to the station site.

Project EHV Test Borings

In preparation for construction of Project EHV *(Electrical Engineering,* August 1958, pp. 669-74), the General Electric Company's extrahigh-voltage power line near Pittsfield, Mass., test borings are being made at sites for substations and 18 giant towers.

The prototype system, 4½ miles long, will carry power at 750,000 volts, providing data for future high-voltage lines. Watching workmen are, from the left, S. Minneci *(pointing)* and J. G. Anderson of General Electric, and Harry Lidikay of the Stone & Webster Engineering Corporation.

Noise Control of Domestic Appliances

R. PLUNKETT

Numerous factors must be considered in designing for noise control of domestic appliances. For example, the environment and use are often as important as the actual magnitude and frequency of the noise. Although measurement of sound is relatively simple, effective interpretation of its meaning generally requires a well-trained expert.

ALTHOUGH a number of criteria for the quantitative description of sound have been published within the last few years,[1-3] they are neither simple enough nor precise enough for use by the designer. Using well-established principles, a designer is able to meet any established sound criterion in any domestic appliance with little or no loss in function, at a price. The problem then becomes one of economics: how much is the customer willing to pay to meet what sound criterion? This problem is complicated by the fact that it is easy enough to make a measurement of sound, but it takes a well-trained expert to interpret its meaning.

One might naturally think that the magnitude of the noise is an important factor; it is, but how important? Most human reactions operate on a logarithmic basis (Weber's law). Each time the physical sensation doubles in amplitude, the subjective reaction increases by the same amount. This also holds true for sound.[4] A pure tone sound will appear to increase by a significant amount when the sound pressure level is roughly tripled (10 db). Less than this increase makes almost no impression after a lapse of time.[5] A really substantial change in measured sound level is necessary before there is any influence on the reputation of a product. This effect is even easier to understand when it is realized that the normal variation in supposedly identical appliances is at least 10 db, and it is usually more.

The actual amount of noise produced is meaningless until it is related to the environment and use. An electric clock which stands on a bedside table must be many times more quiet than an air conditioner which is making the customer more comfortable. In previous years, we have thought that a vacuum cleaner that did not have a powerful sound would be suspected of not doing its job, but now, in a more sophisticated society, we realize that noise cannot add sales appeal. However, it is still true that the large air conditioner in the large (and noisy) store may be allowed to be noisier than the window unit in a small and quiet bedroom.[2]

Customer reaction is influenced still further by past experience. There is little objection to a certain amount of noise from washing machines or dishwashers; they have always been somewhat noisy. On the other hand, over the years refrigerators have been made remarkably quiet; the consumer expects them to become even more quiet.

DESCRIPTION OF NOISE

PROBABLY the most serious problem in noise control is the proper description of noise. A "quality" sound is more acceptable than a "cheap" one. There is remarkably good agreement on whether or not a sound has "quality" but, as yet, we have no quantitative measure. In general, the lower the frequency, the more impressive the sound; automobile manufacturers take advantage of this by using damping materials that inhibit higher frequencies and, as a result, car doors on even inexpensive models shut with a "thud" instead of a clang or tinny rattle.[6] There is, of course, an historical reason for this reaction; i.e., we tend to associate low frequencies with heavier and, therefore, more durable sheet metal. Noise which has most of its energy contained in one single frequency has a typical siren sound and is less easily endured than sound which is spread over more of the frequency spectrum. Again there is a relatively simple explanation for this: The ear has the remarkable property of being able to identify single-frequency tones at levels which are many times lower than the over-all background noise.[7] Thus, a single frequency will stand out, whereas a more complex noise will tend to fade into the background.

The duration of the noise is another important effect. A series of clicks and rattles at irregular intervals are more easily noticed than continuous sound, but may be less objectionable if they are not unexpected. It is a common experience to be wakened by the electric clock stopping when the power goes off. The clock noise itself is not noticeable, but a change in this noise is enough to waken even a sound sleeper. The relative importance of single-frequency and wide-band noise may be assessed.[1] but it is much more difficult to put a number on reaction to clicks and buzzes.

Character of noise in the broad sense is very difficult to assess. Everyone is in favor of musical tones, but one man's music is another man's dissonance. Many people, for example, do not appreciate modern symphonic music. In general, however, we may say that a sound which consists of a fairly large number of constant-amplitude single-frequency notes of about the same magnitude will make a more pleasing impression than

A special article recommended by the Domestic Appliances Subcommittee of the AIEE Domestic and Commercial Applications Committee.

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one in which frequency components are fluctuating in a random manner. On the other hand, when noise is concentrated in a relatively narrow band in the middle of the audio-frequency range, it will interfere with speech comprehension more severely than if it is spread out over the whole spectrum. Recent articles have shown how to put a quantitative measure on the speech interference of constant noise sources.[2]

In short, the annoyance quotient of noise depends upon

1. Background noise
2. Frequency content
3. Magnitude
4. Duration
5. Past experience

All except the last of these factors have been gathered together in a chart which enables the acoustics engineer to predict public reaction to a specific measured noise rather accurately.[8]

HOW NOISE IS PRODUCED

IF WE GO THROUGH this prediction process and discover that the public reaction will be unfavorable, we would then like to know how to change the noise. In order to do that, we must know how the noise is produced. Two major mechanisms are structure-borne vibration and air-flow modulation. The first of these starts with a vibratory force. The force makes some part of the structure vibrate. This part is connected by a transmission path to a loudspeaker which finally radiates sound to the air. A reduction in efficiency of any of these elements will reduce the noise output in like ratio, and the effects are cumulative. If the vibratory force is reduced, for example, by balancing a rotor, the output sound resulting from that cause is reduced proportionately. In the case of one appliance motor, electromagnetic forces were reduced by increasing the air gap, thereby causing the over-all appliance noise to be reduced. In another case, brush noise was reduced by manufacturing smoother commutators. It is often possible to make the response to the force smaller by proper design of the part.[8] In general, making a part stiffer or heavier will reduce its liability to vibration. Decreasing the efficiency of the transmission path is always worthwhile. Common examples are vibration isolators, grommets, and gaskets. In one case, a 3-db reduction in noise was achieved by using simple grommets around the hold-down bolts of an appliance case. Contrary to common opinion, this does not damp or absorb vibration energy; it only keeps it from getting out. It is, of course, clear that any reduction in the efficiency of the loudspeaker will cause a further reduction in sound level. If the radiating surface is broken up into smaller areas and made stiffer, it will radiate less noise; stiffening ribs in the base plate of a food mixer made a 2-to-1 reduction in radiated sound pressure.

The second method of producing noise is modulation of the air flow. One example of this is in fan-driven air,[9] although it is not always the most significant source. There is always some fluctuation in flow corresponding to noise at the blade-passing frequency and its multiples. One method of control is to use that air-moving method which causes the least noise. The next is to use designs which create less fluctuation. Wide-blade home cooling fans make much less noise than the old-fashioned narrow blades. Major improvement in this area is often possible by minor redesign of the air-flow passages and outlets. Careful design of the flow passage of vacuum cleaners accounts for more than 20 db of noise reduction. In one case, the exhaust vent for cooling air in a small appliance had three times the area of the intake. Cutting down this area made a sizable reduction in noise with no loss in cooling efficiency.

FREQUENCY ANALYSIS

ONCE AN APPLIANCE IS BUILT, it is important to find the source of the greatest noise. The best clue is an accurate frequency analysis. Frequency analysis of a small, high-speed appliance driven by a series motor showed that the worst component had a noise frequency corresponding to eight times the rotor frequency. There were eight commutator bars which caused eight electrical surges per revolution. Measurements made while running the motor on a-c and d-c at various loads and speeds led to some minor electrical design changes which reduced this noise. Accuracy of frequency measurement is particularly important in appliances driven by induction motors when these measurements will show whether the original source is caused by line frequency (electromagnetic forces)[10] or rotating speed (mechanical or unbalance forces).

The radiation pattern or directionality of the noise may give some clues about noise production. If the highest sound level is in the exhaust air, it is caused by flow modulation or fan noise; if the highest sound level is on one side of a machine, it will be caused by equipment fastened to that side. A survey of this type led to the stiffened base plate mentioned earlier. Another useful experimental procedure is to eliminate various parts and see how they affect the noise. Running the fan and the compressor separately on a window air conditioner will quickly show which is the worst offender. Using both a-c and d-c power to run a series motor will show whether electromagnetic forces are caused by line frequency, motor characteristics, or interaction between them. For an induction motor, a similar check may be made by changing line frequency over the range from 50 to 70 cps.[10] This is also related to the technique of temporary modification of parts such as by damping, stiffening, or mass loading. It is often useful to check the effect of making modifications that would not be practical for the final design.

Sonance design, i.e. design for proper sound, must start with the first design ideas. Improper original design may make it impossible ever to achieve satisfactory noise control at a reasonable price. As in most design problems, the most useful information is experience. A designer should try to incorporate those ideas that have

led to good sonance design and avoid those that have given bad results. A good fundamental background in acoustic theory can often help the designer to decide the qualitative effects of design changes. This will show him why heavy partitions or walls cut down sound transmissions and why double walls are better. It will also tell him why wall treatment will not reduce the noise in the vicinity of a machine, etc.

There are certain quantitative calculations that are useful in advance of design. The sound level from fans is fairly well known and the attenuation in ducts can be calculated.[11] It is possible to calculate some of the circumstances that lead to high motor noise. There are a few other cases of this general type but there are not many times when it is possible and profitable to make quantitative calculations in the sonance design of small appliances.

It is impossible to establish, in advance, the environment in which an appliance will operate. In fact, it may be quite different for different buyers of the same product. For this reason, sound pressure levels measured under free field conditions are not sufficient. Recent work shows that total power measurements[12] with a frequency spectrum will give the characteristics of most machines, although it may be desirable to give the directionality in some cases.

MODIFICATION

ONCE A PROTOTYPE HAS BEEN DESIGNED, there is often a problem of suitable modification to improve the sound characteristics. The principles can be derived from an understanding of the elements of noise production listed earlier. We can attempt to reduce the force by balancing or reducing magnetic fluctuations. We can reduce the response to a vibratory force by making the part heavier, or, if at resonance, by detuning or damping. We can attenuate the noise or vibration by duct treatment or by vibration isolation. We can reduce the effectiveness of radiation of noise by damping or stiffening the radiating area. Finally, we can improve the character of the noise by selective suppression of certain frequency bands or by reducing rattling.

We see from the foregoing examples that proper measurement and specification of noise makes the problem of sonance design simpler. There are certain fundamental principles of design which make control easier. Application of these same principles indicates the proper means for control of noise in equipment already designed.

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Closed-Circuit Television in Steel Mill

Television cameras focused through portholes into reheating ovens of the Jones & Laughlin steel plant in Aliquippa, Pa., allow furnace chargers to observe operations and control movement of white-hot steel slabs by watching television screens 100 feet from the furnaces. Cameras and receivers, operating over a closed circuit, were developed by the Radio Corporation of America.

In this installation, two RCA *ITV-6* cameras scan the scene inside the 2,400° ovens and transmit pictures to the control room where they appear on monitors. The operator, or furnace charger, must keep a supply of hot slabs moving through the mill for further processing. The furnaces have to be kept fully supplied with the glowing slabs to prevent a jam-up. The charger also must see that the slabs are sent on their way with split-second precision to prevent cooling before they arrive at the rolling section.

A Torsional Vibrations Problem

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TORSIONAL vibration studies of simple mechanical systems are usually handled by methods which, while not difficult, often require the expenditure of considerable time when done by hand. The use of a digital computer shortens the time considerably. One method frequently used is the Holzer table calculations resulting in the determination of the natural frequencies of the system. Another method is a matrix solution of the differential equations of the system.

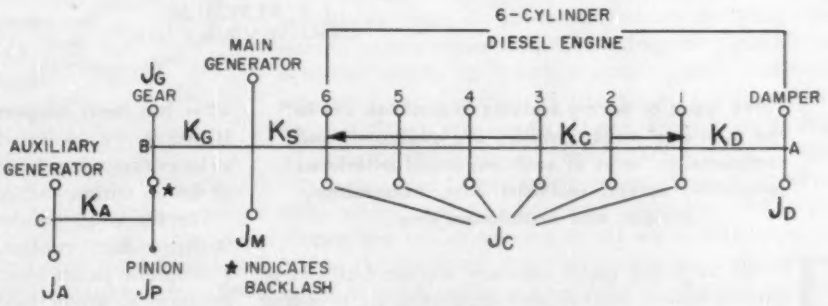

Fig. 1. Schematic of equivalent system.

While these methods produce good results for simpler systems, the introduction of nonlinear driving functions; discontinuities in the form of gear backlash; and system components, such as hydraulically connected vibration dampers, often require simplifying assumptions which affect the validity of the results. The proposed method overcomes some of these difficulties and predicts the actual operation of the system more accurately. Using the analog computer, nonlinearities and discontinuities in the system function, as well as in the driving function, can be accounted for.

The system studied includes a 6-cylinder diesel engine with its torsional damper and two direct-current generators. The main generator is direct-driven by the engine, while the auxiliary generator is driven through a set of spur gears from the main generator. A simplified schematic diagram of the system is shown in Fig. 1. The system is broken into discrete lumps and the standard practice for analyzing reciprocating engines is used. The rotating and reciprocating parts are lumped to form average equivalent moments of inertia. The actual system is distributed, of course, and not lumped.

A lumped mass torsional spring analogy of a simple mechanical system is shown in Fig. 2, and is used as the basis for the analog computer simulation.

The analog computer was used to simulate the system shown in Fig. 1, including the driving torque pulses of the diesel engine, the torsional damper, and the gear branch with backlash. The derivations of analog computer parameters for all these simulations are included in the report. During the simulation, the actual system from which test data were obtained was available. A Cox recorder was used to take recordings of the damper output, main generator shaft output, and auxiliary generator output (points A, B, and C in Fig. 1). The Cox recorder was simulated, and readings were also taken at

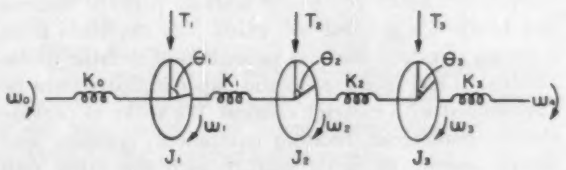

Fig. 2. Schematic of a typical system. T_1, T_2, and T_3 are the externally applied driving or load torques; J_1, J_2, and J_3 are the moments of inertia of the lumped masses; ω_1, ω_2, and ω_3 are the angular velocities of the masses; θ_1, θ_2, and θ_3 are the angular displacements of the masses with respect to an arbitrary datum; and K_0, K_1, K_2, and K_3 are the torsional spring constants of the connecting links between the various lumped masses.

the same locations of the simulation. Comparisons of test and computer data are included in the report. There appears to be good correspondence between test and computer data of both magnitude and frequency.

An interesting observation was that the order and amplitude of vibration are affected by the amount of backlash between gear teeth. Only qualitative results have been obtained; but they indicate that, as backlash is increased, the vibration amplitude increases and the vibration frequency changes up to a point. These qualitative results agree with prior analytical work done by W. A. Tuplin in England. Quantitative relationships for this are not established in this report. Results indicate that this method produces better results for a complex system than the Holzer calculation because nonlinearities and discontinuities can be included.

Digest of paper 58-502, "An Analog Computer Study of a Torsional Vibrations Problem," recommended by the AIEE Land Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE–ASME Railroad Conference, Cleveland, Ohio, April 9-10, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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Evaluation of Wiring Systems for the Pulp and Paper Industry

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Three types of wiring systems in common use in the pulp and paper industry are evaluated and compared in terms of such important criteria as reliability, safety, installed cost, adaptability, weight, and installation time.

IN the pulp and paper industry, storage facilities to protect against unavoidable shutdowns are provided for wood, wood chips, pulp stock, chemicals, fuels, and other commodities. Alternating current, by its very nature, cannot be stored. A failure of the mill electrical source or distribution system will bring about an instantaneous cessation of mill production, followed by sometimes lengthy repair and start-up periods. Because this fundamental condition exists, any deviation from a design standard that has proved itself reliable under conditions met in the pulp and paper industry must be approached with extreme caution. We strive to provide electric switchgear, rotating equipment, controls, and wiring systems of equal quality with the other mill facilities and production machinery. Under no circumstances, whether they be economical or physical, should any part of the electric plant be designed below the accepted standards for other equipment within the mill.

In view of increasing costs of material and labor and decreasing availability of funds for expansion, it is fitting that existing design standards be re-evaluated. The purpose of this article is to evaluate, in small measure, three types of wiring systems in common use in the pulp and paper industry. For purposes of brevity, this evaluation is confined to our largest electric wiring plant, the 600-volt secondary distribution system.

During the initial phases of research toward the preparation of this article, it was found that the three 600-volt systems most commonly applied in the past or at present are:

1. Single-conductor power and control cable installed in rigid steel conduit raceways.
2. Multiconductor armored power and control cable installed on cable ladders.
3. Multiconductor nonmetallic jacketed power and control cable installed in expanded metal trays.

There are many ways and methods of applying these three general systems, both in material used and in installation procedures. In order to permit evaluation on the basis of comparable systems, general design standards for the three systems were established. This selection is by no means complete, nor does it represent what has been adopted by the mills in the industry. However, we do feel that it enables the three systems to be evaluated without too much differential in quality of design within each system.

For the single-conductor system, we have selected a 90-degree Butyl rubber insulated copper conductor with a neoprene jacket over the insulation for moisture and mechanical protection. Starting with this basic single conductor, jute fillers and an over-all neoprene jacket were added to obtain the multiconductor cable. To obtain the armored cable, a 30-mil aluminum interlocked armor and an over-all 50-mil polyvinyl chloride jacket were added. For the raceways, we selected hot-dip galvanized rigid steel conduit sized in accordance with the National Electrical Safety Code, 1956 Edition, for the single conductor system; 20-inch aluminum cable ladders and 20-inch aluminum expanded metal trays of conventional design for the armored and nonarmored multiconductor systems, respectively.

For support systems, we have considered standard rod and channel supports for all three systems, using Korn clamps for securing conduit, cable clamps for fastening cable in the rack, and marlin ties on the nonarmored cable at reasonable spacing.

Having established these three basic designs, we can proceed with our evaluation. The fundamental features of any wiring system can be generally rated in the categories outlined in Table I.

The first category to be considered is reliability of service under normal and adverse operating conditions of atmosphere, temperature, and mechanical abuse. In the pulp and paper industry, the atmosphere is abundant with moisture, corrosive vapors, solids, liquids, and organic and inorganic dusts. Mill temperatures vary from subzero outside in winter to more than 180 F in the vicinity of boilers and under machine and dryer hoods. Our wiring systems must be installed in many cases where they are subject to mechanical damage from falling logs, and tools and material of the other trades.

Hot-dip galvanized rigid steel conduit has proved

Revised text of a conference paper presented at the AIEE Pulp and Paper Conference, Raleigh, N. C., Mar. 27-29, 1958. Recommended for publication by the Pulp and Paper Subcommittee of the AIEE General Industry Applications Committee.

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The author acknowledges the invaluable assistance of the following: Ray McKinley, B. J. Mulvey, W. G. Short, and Lynn Sylvester of General Electric Co., Wire and Cable Div., Bridgeport, Conn.; M. J. Osborne, Bowaters Southern Paper Corp., Calhoun, Tenn.; W. S. Lindsay, Duncan Electric Co., Chattanooga, Tenn.; J. Loudermilk, Simplex Wire and Cable Co., Birmingham, Ala.; M. M. Stokely, J. E. Sirrine Co., Greenville, S. C.; L. J. Randall and J. T. Simmons, Walter Kidde Co., Houston, Texas.

Table I. Rating Summary

Category of Evaluation	Wiring System Rating		
	Rigid Steel Conduit	Armored Cable	Neoprene Cable
1. Reliability of service	Very good	Good	Fair
2. Adaptability to changes and additions	Poor	Good	Very good
3. Installed cost	100% cost	90% cost	75% cost
4. Space requirements	Poor	Good	Very good
5. Weight of material	Poor	Good	Very good
6. Time required for installation	Poor	Good	Good
7. Salvage value for material used	Poor	Good	Good
8. Safety to personnel and equipment	Good	Good	Fair
9. Appearance	Good	Very good	Good

itself resistant to most corrosive conditions found in sulfate mills. Experience has proved that when installed properly, with all joints "doped," it will stand up extremely well.

The PVC (polyvinyl chloride) jacketed aluminum armored cable can be rated higher than rigid steel conduit in regard to resistance to corrosion, for where we have only the thin galvanizing to protect the steel, we have the PVC jacket and the aluminum armor fighting the chemical attack. PVC compounds have very good resistance to chemical attack from strong bases, acids, oils, and oil derivatives.[1] Aluminum is resistant to chemical attack except from caustic or highly alkaline media. In the Calhoun, Tenn., mill of the Bowaters Southern Paper Corporation, a 3-foot section of aluminum trough was eaten away entirely when exposed to direct contact with chips impregnated with cold soda. However, armored cables within the rack suffered no apparent damage, as they were jacketed with 50 mils of PVC compound.

Neoprene can be rated only good in its resistance to chemical attack and, therefore, will not stand up as well as the other two systems.[1] Metal sheaths are the only true barriers to any outside environment. Nonmetallic sheaths are a special problem where the insulation itself must resist environmental effects. An ever-present danger is that of tearing or puncturing the neoprene jacket. In this event, hydrochloric acid, abundant in the mills, would act to chlorinate the rubber insulation, causing it to become cracked and brittle.[2]

Conduit, installed properly, is greatly resistant to entrance of moisture. Armored cable, by virtue of the PVC jacket, the interlocked armor, and the inner neoprene jacket, runs a close second. Again, with neoprene jacketed cable there is the danger of puncturing the only moisture protection, the neoprene jacket itself.

The possibility of fire, as a result of loose stock, paper, and other flammable materials, is always present in these mills. Of the three systems, armored cable stands out as resistant to damage from mild and semi-mild fires. In the Calhoun mill, there was an instance of complete burn-up of a transformer ground resistor on a sustained ground fault. The fire was directly underneath a rack congested with armored cables. None of the circuits developed a fault, although the PVC jackets were completely destroyed. After test, the cables were returned to service. Reports have been received both from this industry and from allied industries where, in fires, all systems except the armored cables were destroyed or rendered unfit for future service.

In November 1957, a cable fire test was conducted at Calhoun using the three types of systems being considered in this evaluation. The cables were placed on a 10-foot section of 20-inch aluminum cable rack and supported approximately 4 feet above a kerosene oil fire. All phases were connected to a 480-volt source and all failures detected were conductor to ground. Unfortunately, the wind caused the flames to blow away from cables 1 and 2 so that these cables were not in the intense portion of the fire at all times. As shown in Table II, the three single-conductor neoprene cables failed in much less time than did the other cables. The conduit-enclosed and armored cables appeared to withstand the effects of the fire equally when their location with respect to the intense portion of the fire is taken into consideration.

In regard to mechanical abuse, there is no doubt that rigid conduit is the better wiring system. Table III shows the results of a crush test performed by the General Electric Company in June 1957.

The cables tested were neoprene jacketed versatol geoprene insulated 3-conductor no. 4/0 AWG armored and unarmored, and three single-conductor no. 4/0 AWG in 2½-inch rigid steel conduit. The cables were placed on the flat bed of the testing machine with a 4-by 4-inch plate between the cables and the press beam. The beam was lowered until all cables had failed. During the test, a voltage of 1,000 volts a-c was applied to each cable, conductors to ground.

You will note that the unarmored cable, as would be expected, was the first to fail. The armored cable withstood roughly twice the pressure at which the unarmored cable failed, while the rigid steel enclosed cables did not fail until the pressure reached five times the value at which the first cable failed. The armored cable diameter was 2.03 inches before test and 1.65 inches at failure—a reduction of 19%. The conduit was

Table II. Cable Fire Test Results

Cable No.	Description	Time of Failure, minutes	Temperature at Failure, degrees F
1	3-conductor no. 12, neoprene	8.5	860
2	3-conductor no. 12, conduit	8.0	830
3	3-conductor no. 10, armored	6.5	900
4	3-conductor no. 6, armored	7.5	900
5	3 single-conductor no. 10, neoprene	2.0	950
6	3 single-conductor no. 6, conduit	6.5	900

Table III. Cable Crush Test Results

Assembly	Force, pounds	Remarks
Cable only	5,780	Armor removed, metal tape as ground electrode
Armored cable	9,280	
Cable in conduit	32,500	2½-inch steel conduit, yield point 42,100 pounds

2.38 inches before test and 1.38 inches at failure—a reduction of 42%.

Neoprene can be rated only fair with respect to tear resistance and good as to abrasion resistance.[1] Therefore, it cannot be rated anywhere near the other systems on reliability of service under adverse conditions of mechanical abuse. It is also much more susceptible to mechanical damage during installation.

The next category is adaptability to changes and additions. Neoprene jacketed cable systems are most adaptable to both changes and additions—the only possible exception being where cables must be removed or repulled during rerouting inasmuch as this system, as stated previously, is susceptible to mechanical damage. Armored cable systems except for more weight and setup requirements are almost as adaptable to the rerouting of existing or the adding of new circuits. Rigid conduit is the least adaptable to changes and additions. The portion to be rerouted usually must be cut out and scrapped, and new conduit and wire must be installed.

Installed cost is an important category, inasmuch as it directly affects ability to expand, to revise, and to improve electric plant facilities. Of all the categories, this was the most difficult to evaluate. In an attempt to arrive at realistic cost figures on sizable wiring systems, we approached several major electrical contracting and consulting engineering firms. At the same time, we accumulated system cost figures from within our own organization. The net result of this investigation is that our unit costs appear to contradict those quoted in trade magazine articles and manufacturer's published literature. However, very little substantiated opposing units were presented to us, and as a result, we feel that, in general, our units are a true prediction of relative costs of the three systems under the estimating conditions established.

To arrive at our units, we calculated the cost of a full raceway of equivalent circuits 100 feet long without change in direction. Dividing by the footage gives unit cost per foot. Next, this unit cost per foot was divided by the ampere capacity of each of the system circuits and converted to percentage cost per ampere foot with the rigid conduit system as the base or 100% cost.

The results are shown graphically in Fig. 1. From these curves, it may be assumed that on a large job (in excess of $100,000 for wiring material and labor) the probable percentage costs, considering short cuts in installation procedures, more economical raceway arrangement, and changes in direction of raceways, would be 100% for rigid conduit, 90% for armored cable, and 75 to 80% for neoprene jacketed cable systems. Of course, these unit costs are on the basis of a single layer of cables or conduit. Per-cent cost for the armored and neoprene cable systems could be made somewhat more attractive by using multiple layers where possible, despite the derating required if this were done.

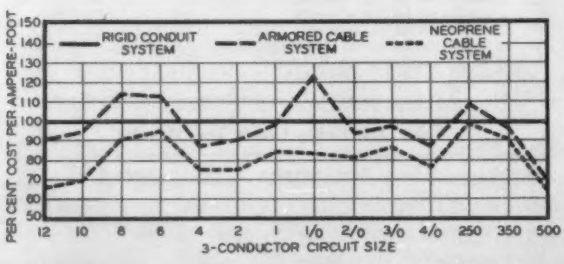

Fig. 1. Installed cost.

Table IV. Number of 3-Wire Circuits in Horizontal Space of 20 Inches *

Size, AWG	Conduit	Armored	Neoprene
12	13	14	20
10	13	13	19
8	13	11	15
6	10	10	13
4	7	9	11
2	7	8	10
1	7	7	9
110	5	6	8
2/0	5	6	8
3/0	5	6	7
4/0	4	5	7
250	4	5	6
350	4	4	5
500	3	4	5

*Spacing, one half the conduit or cable diameter.

Table V. Average Per-Cent Installation Time

System	Installation Time, per-cent
Rigid conduit	100 (Poor)
Armored cable	60 (Good)
Neoprene jacketed cable	50 (Good)

If single rows horizontally are considered, the number of 3-wire circuits in a 20-inch space is as shown in Table IV. It can be seen that from two to seven more neoprene jacketed cable circuits can be installed than rigid conduit circuits. Although armored cable does not compare as favorably in all sizes, it is obvious that more armored cable can be installed in a given space than rigid conduit. On a large system, the use of armored cable would probably realize 20% space saving while the use of neoprene jacketed cable would realize up to 50%. By the use of multiple layers of armored and neoprene jacketed cables, even greater space could be saved, which greatly favors the use of these two systems, particularly neoprene jacketed cable.

In regard to weight of material, rigid conduit imposes a greater weight per ampere-foot than either of the other two systems. The weight differential between multiconductor neoprene jacketed cable and aluminum interlocked armored cable on a large system would be on the order of 30% in favor of the neoprene jacketed cable.

By actual test, within the Jersey Central Power and Light Company System, it was found that through the use of neoprene jacketed cable a ton of steel was saved in every 60 feet of cable trough or 250 tons of steel in the E. H. Werner Station's addition of a 62,500-kw unit.[3]

Using the labor costs per 100 feet of circuit we developed, a comparison of time required for installation is shown in Table V.

Salvage value of single-conductor cables in rigid steel conduit can be considered negligible as far as reuse in current-carrying circuits is concerned. Straight sections of conduit and standard bends can be salvaged to some extent, but the labor cost to remove is almost as great as that to install it originally. Armored cable and neoprene jacketed cable are both approximately 90% salvageable, though caution must be exercised in their removal, particularly with neoprene jacketed cable.

Safety to personnel and equipment is one of the most important considerations in the design of this wiring system. Rigid steel conduit affords maximum mechanical protection and, for this reason, deserves a high safety rating in this respect. However, in regard to electrical safety, it has been found that when a fault to ground occurs on a rigid conduit system, a high proportion of the fault current travels in the steel conduit even when a separate ground wire is in the raceway.[4] Inasmuch as joints are "doped" to prevent rust and couplings, bushings, and locknuts at terminations frequently loosen, we have the production of arcs that will provide a generous supply of sparks and hot metal until the joints are fused into a good connection. By this time, the circuit will have been severely damaged.

Properly bonded sections of aluminum cable rack or basket provide good ground return paths. The aluminum armor of armored cable, in addition, provides an excellent ground return path when properly terminated, as it approaches the optimum arrangement of an internal grounding conductor.

Neoprene jacketed cable could not be rated equal to the other two systems because of its susceptibility to mechanical damage.

Although secondary in importance to the previously mentioned points of evaluation, the general appearance of our wiring system must be given due consideration. Any of the three systems being considered can, by a little extra design effort and installation control, be made pleasing in appearance. The system that lends itself more to modern wiring system "attractiveness" is the armored cable system. With armored cable, it is much easier to eliminate congestion and bulkiness and to include concentric bending and optimum routing than with the rigid conduit system. In comparison with neoprene jacketed cable, both the armored cable and its support system are more in keeping with heavy industrial electrical construction concepts.

All of the evaluation ratings assigned have been combined in Table I. All electrical engineers realize that from a design standpoint, reliability of service and safety to personnel and equipment is of first consideration. However, in our work we must take a broad view—our design axiom is "economy without sacrifice of system flexibility and quality." The correct application of cables—after appropriate consideration has been given to safety, adequacy, reliability, appearance, and mechanical design—is that which results in an optimum installed cost coupled with minimum total annual expense.

Single-conductor cable installed in rigid steel conduit is the best wiring system that can now be installed in the pulp and paper industry. Neoprene jacketed cable in expanded metal trays should be applied with caution and only in areas where its features are acceptable and are consistent with good design practice. In light of favorable experience and economic considerations, we would recommend extension of the application of aluminum armored cable in our industry.

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Computer for Flight Control

Installed at the Civil Aeronautics Administration's air route traffic control center in Indianapolis, Ind., this IBM (International Business Machines Corp.) *650* RAMAC is the first electronic computer placed into operational service in the CAA's planned computer network for modernizing air traffic control. Information on flight plans is fed into the system on punched cards, such as the one being examined here by Glen C. Lenzer, deputy chief of the CAA center, and the machine automatically computes and prints flight progress data, estimates flight arrival times over check points, and determines air space conflicts in flight plans. Heart of the IBM *650* RAMAC is the disk memory unit *(right)*, composed of 50 magnetic disks providing a total storage capacity of 6 million digits.

Supervisory Control on the Bonneville System

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THE BONNEVILLE Power Administration (BPA) transmission network serves the load areas of Washington, Oregon, northern Idaho, and Montana. It consists of approximately 7,600 miles of transmission lines and 190 substations. In the past 4 years, the number of stations operated by supervisory control has increased from 4 to 23. The majority of the supervisory control equipment in service is operating over power line carrier channels of various types. A few installations operate over leased line and cable, and some equipment has been installed and tested for operation over microwave.

The use of supervisory control offers both economic and operating advantages. However, these advantages cannot be fully realized unless equipment performance is reliable. The purpose of this article is to outline to some extent the use of supervisory control on the BPA system and to discuss the requirements of an acceptable installation, along with some of the problems of obtaining such an installation.

False operation of any controlled apparatus may cause serious customer outage and damage to expensive equipment. This type of trouble cannot be tolerated. It is usually the result of inadequate design due to lack of familiarity with actual field conditions. Equipment which will provide reliable service over wire line or cable circuits may be susceptible to misoperation by noise when used over power line carrier or microwave channels. This noise may be different and much more severe than any that can conveniently be generated in the laboratory. In well-designed supervisory control equipment, the coding should be complex enough to prevent operation by noise. Additional safety can be realized by the use of a squelch circuit to block sustained channel noise from the code receiving relays. This will also reduce wear on the relays.

Basically, a supervisory control installation is required to provide supervision and control of one or more remote stations from a single location. The number and type of functions required will vary with the amount and variety of equipment at the station. The following types of functions, where applicable, are required of BPA installations:

1. Supervision and control of circuit breakers, motor operated disconnects, and synchronous condensers.
2. Control of transformer bank tap position with provision for out-of-step alarm.
3. Telemetering of voltages, loads, and transformer tap positions.
4. Supervision of alarm contacts for transformer temperature, fire, battery voltage, bearing temperature, door entry, etc.
5. Supervision of Test-Normal switch and interconnecting channel.

Supervisory control equipment is set up back to back at one location in order to check its operation prior to installation. Every point is checked for proper operation in accordance with the specifications. All wiring and relays are visually checked for shipping damage. These tests are conducted with the co-operation of personnel responsible for the installation and maintenance of the equipment. This is particularly valuable to maintenance personnel if the equipment is new to them.

Circuit breaker controls are not connected to a completed installation until after field tests indicate that the equipment will function reliably without danger of false operation. In general, the means of obtaining conclusive test data consists of wiring two or more auxiliary relays to simulate circuit breakers and connecting them to the points most likely to be affected by noise or abnormal conditions. In addition, counters are connected ahead of the interposing relays to indicate all operations initiated by the supervisory control relays. The equipment is operated regularly and subjected to channel noise and other abnormal conditions. It is left on test until the results obtained indicate that performance will be reliable.

Supervisory control equipment involves the operation of numerous telephone type relays. In general, these are meant to switch small noninductive currents. However, sparking contacts have been a major cause of maintenance and outage troubles. The use of rectifier type contact protectors provides a satisfactory solution to this problem.

A large part of the carrier equipment used by BPA for supervisory control channels also provides voice communication to the controlled station. This equipment operates from a power supply of 117-volts a-c. Outages caused by vacuum tube failure or low emission were the main source of trouble in this equipment. Some of the receiver tubes are operated as switching tubes with intermittent plate current. The standard tube has very poor life in this use. Replacing these tubes with equivalent long-life or computer type tubes has resulted in an increase in tube life of approximately 3 to 1. The addition of voltage regulators in the power supply and transformers for 6-volt filament operation have also helped to reduce outage time and maintenance costs.

Digest of paper 58-1021, "The Application of Supervisory Control on the Bonneville System," recommended by the AIEE Substations Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Pacific General Meeting, Sacramento, Calif., Aug. 19-22, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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The Upper Raquette River Power Project

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THE UPPER RAQUETTE RIVER power project is the final phase of a program begun many years ago by the Niagara Mohawk Power Corporation to harness completely the Raquette River of northern New York State for power production purposes.

The first step in this project was the construction of a storage reservoir at Carry Falls near the head of the river with facilities for regulating the river flow to all downstream plants. This was followed by five generating stations at favorable sites along a 15-mile stretch of the river below the reservoir. With an aggregate capacity of approximately 100,000 kw, and operated normally as peak-load plants, annual production is expected to exceed 400 million kw-hr.

Automation is heavily stressed in this development permitting unattended operation by remote supervisory control from an area operations center located at an older plant downstream. The starting or shutdown of any generating unit is a fully automatic operation initiated by a single coded signal transmitted from the operations center to the generating plant over a telephone circuit. Remote control of generator power and reactive outputs, and control of sluice and tainter gates, is effected in the same manner with telemetered indications for the controlling operator's guidance.

Suitable protective devices are liberally applied to both the hydraulic and electric equipment for the detection of abnormal or emergency conditions. These devices initiate automatic corrective action to prevent or minimize damage to equipment with alarm indication to the remote operator.

Utilizing the supervisory control system and special supplementary control devices, the five stations are designed for automatic load frequency control operation on a sequential loading basis for maximum economy. Load control impulses originating in the master control equipment at Syracuse may be routed to these stations for sequential loading and unloading with the sequence automatically modified as required to maintain normal pond level at each plant.

At each site, the generating unit and its associated auxiliary and control equipment is housed in a reinforced concrete building. These buildings are identical in design and construction except for minor modifications dictated by some variation in the installed equipment. Located immediately adjacent to each powerhouse is a small switchyard containing the power transformer and the high-voltage switchgear. All of the plants feed into the same single-circuit 115-kv transmission line for power delivery into the Niagara Mohawk system.

Fig. 1. Aerial view of Raquette River generating station.

Because of the peculiar geological conditions encountered in the area, it was found necessary to install an extensive grounding system at each location, interconnected by the overhead ground wires and a continuous counterpoise to obtain a satisfactory low resistance ground. This was essential because of protective problems on the telephone circuits in aerial cable interconnecting the various plants and the remote operations center.

The severe winter weather common to the area made necessary unusual precautions to insure satisfactory performance of equipment under such adverse conditions. The head gates, tainter gates, and sluice gates are equipped with hairpin type electric heaters at critical locations to prevent ice accumulation which could interfere with their normal operation.

To prevent excessive ice formation in the surge tanks located at the two stations having long pipelines, a system of electric water heaters is provided. Heated water is discharged across the surface of the water in the surge tanks by a series of nozzles. Results with this system have been entirely satisfactory during several unusual cold periods occurring since operation began.

An exhaustive program of testing at the time of initial start-up and preliminary operation served to disclose various incipient troubles and permit immediate remedial action. Consequently, since the start of commercial operation the development has remained generally trouble free and performance has been up to expectations.

Digest of paper 58-876, "Electrical Features of the Upper Raquette River Power Project," recommended by the AIEE Power Generation Committee for presentation at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

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Double-Bus Distribution Substations

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The design and reasons for adoption of double-bus switchgear on the Detroit Edison system are discussed. Its use has resulted in substantial savings in cost and operating advantages as compared with single-bus switchgear design.

IN RECENT YEARS, the Detroit Edison Company has employed a double-bus arrangement as the preferred design for distribution substations. Other companies with similar operating conditions and problems may find an application of the double-bus arrangement practical for use on their distribution systems.

Two basic substation designs have been utilized in distribution substations having a minimum capability of 5,000 kva. These are generally referred to as single bus and double-bus, wherein the power transformers

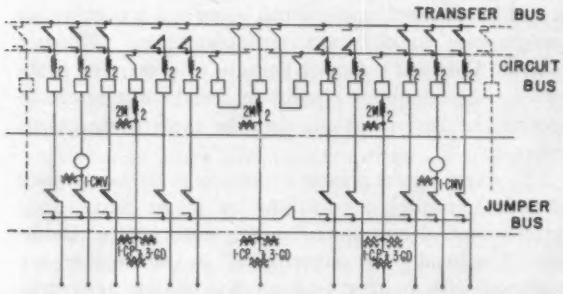

Fig. 1. One-line diagram, radial double bus with jumper bus.

may be operated in parallel or radially. The power transformers may be rated from 2,500 kva each to a maximum of 10,000 kva each. The substations described in this article are for application on a 4,800-volt ungrounded delta distribution system. The subtransmission system feeding these substations is a 24-kv or 41.6-kv system, in each case solidly grounded.

SWITCHGEAR DESIGN

THE SWITCHGEAR DESIGNS presented in this article have been subject to two basic criteria, namely: (1) The one-line diagram must be equally functional with any number of power transformers and outgoing lines (or circuits) beyond the original complement; (2) The addition of power transformers and regulators and switchgear must be possible without serious alteration or replacement of the original structures, equipment mats, and switchgear assemblies.

Radial Double-Bus Substation. Radial operation is accomplished when each substation transformer has an independent subtransmission feed and is not electrically connected to any other transformer on the secondary side. Provision is made, however, for transferring the load automatically from one transformer to another transformer in the event of transformer interruption. Fig. 1 shows a radial substation diagram with three transformers installed and two bus sections. Each bus section includes all the positions that have a common circuit bus or lower bus. The transfer bus or upper bus is common to all outgoing line positions in the particular substation. Each bus section also includes one bus-tie position that is automatically operated to accomplish transformer throwover in radially operated substations. One transformer feeds the transfer bus as shown in Fig. 1. The remaining transformers feed their respective circuit busses.

The selective-type disconnects permit transferring of circuit loads from one position to another without interruption to service. A circuit may be transferred from one bus to another by first closing the bus-tie breaker and then moving one blade of each phase disconnect to the opposite bus. The remaining blades may then be moved to the opposite bus and the bus-tie breaker opened. The transfer is reasonably fast and without interruption to service. The bus-tie breaker is closed during this procedure to provide a continuous path for any circulating current that may be established. The majority of substations of this design are originally placed in service with two transformers and one bus section. Bus links are available in the transfer bus feed position for temporarily extending the circuit bus, thus permitting outgoing line positions to be originally installed in future bus sections. A fully loaded bus section has from five to seven circuits. All switchgear units are designed to permit any sequences in the one-line arrangement.

Fig. 1 also shows a jumper bus that is sometimes incorporated in the distribution substation. The jumper bus allows the load of one or more circuits to be carried by another circuit position. Voltage and load requirements usually limit this jumpering operation to one position for each jumper bus section. This bus permits maintenance operations on outgoing line positions without line transfers outside the substation.

Automatic throwover between transformers and respective bus-tie positions is accomplished with time de-

Revised text of District paper DP58-518, presented at the AIEE Great Lakes District Meeting, East Lansing, Mich., May 5-7, 1958, at a session sponsored by the AIEE Substations Committee.

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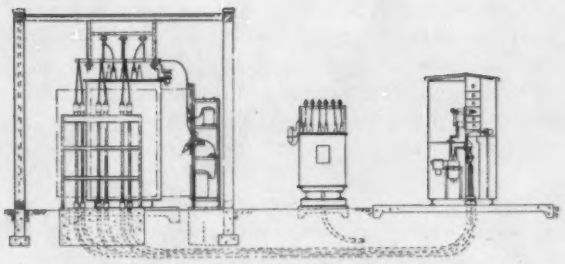


Fig. 2. Cross section, radial outdoor double-bus substation.

lay under voltage relays on each incoming line position. Loss of potential on an incoming line position trips the incoming line breaker and subsequently closes the respective bus-tie breaker. Overcurrent relays are provided to block throwover operation when the loss of potential is accompanied with fault current. Upon restoration of voltage to the affected unit, the incoming line breaker closes, momentarily paralleling transformers, and then the bus-tie breaker trips. Relays determine that the sources are synchronous before permitting this operation. The bus-tie breaker is operated from the auxiliary switch contacts on the incoming line breaker and is, therefore, not equipped with current transformers. All outgoing line positions are equipped with 3-shot reclosing relays and inverse time overcurrent relays. The initial reclosure is usually instantaneous. Overcurrent relays are applied in each of two phases. Back-up protection on outgoing line breakers is usually limited to reliance on transformer primary fuses or subtransmission switching.

Fig. 2 is a cross section of major equipment arranged in a radial outdoor substation. Fig. 3 shows a planned view of this arrangement and Fig. 4 is a perspective showing the front and side elevations. The outdoor arrangement provides masonry enclosures for transformers and bus regulators. Circuit regulators, where required for supplemental regulation, are located between the switchgear line and the transformer enclosures. The bus-tie breaker cell encloses the control power distribution panel, throwover panel, and breaker-tripping battery. The headquarters building includes alarm and communications equipment, and serves as the operator's office. The transformer enclosures may also be arranged at right angles to that shown to meet various property requirements and/or subtransmission feeds.

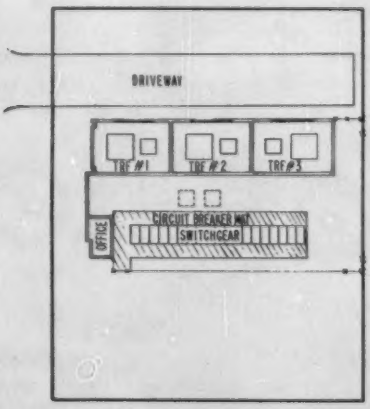


Fig. 3. Plan view, radial outdoor substation.

Parallel Double-Bus Substation. Parallel operation of transformers on the distribution voltage side results in better service continuity. The loss of one transformer does not cause a throwover operation and the accompanying momentary interruption. Instead, the incoming line breaker trips and the load is carried on the remaining transformers either directly or through a reactor system. Fig. 5 shows a 3-transformer substation with each main bus connected through reactors to a reactor bus. The reactors are chosen to reduce the available fault current and yet provide emergency bus feeds within certain voltage limits. Parallel operation of substations on the Detroit Edison system is confined to

Fig. 4. Perspective, radial outdoor substation.

areas served with a network-type distribution system. Reactors are rated 1,200 amperes continuous and 8% reactance on a 10,000-kva base. The bus-tie breakers are manually operated for maintenance shutdowns. Directional overcurrent relays are used on incoming line breakers. Potential for these relays is provided from potential transformers on the reactor bus. Total current differential relaying is applied on the reactor bus. Partial current differential relaying is installed on the incoming line and reactor breakers for each main bus.

Load-break stab-type disconnects are usually installed in separate steel housings on each network feeder position. Network feeders commonly have two 3-conductor outgoing cables to the network system, as shown in Fig. 5. The load-break disconnects accomplish interruption of charging current after the network protector has been opened.

Radial Single-Bus Substation. A one-line diagram of conventional single-bus automatic throwover type substation is given in Fig. 6. The relaying is identical with that used for double-bus radial operation. Disconnects merely provide isolation of breaker and associated

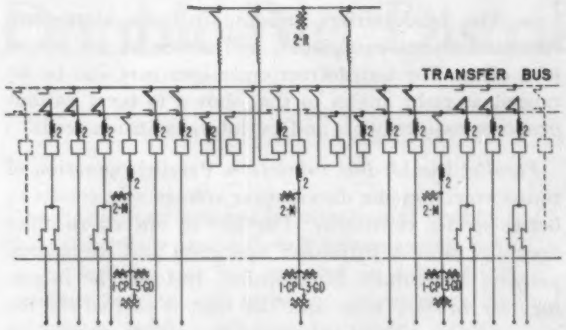


Fig. 5. One-line diagram, parallel double bus.

equipment for maintenance purposes. The disconnects are normally connected to the respective circuit bus with copper bar bus taps. This allows a horizontal bus configuration and, therefore, an over-all lower height. The basis for preference for the double-bus design is largely established in this article in comparisons with the single-bus design.

Radial Expansible Double-Bus Substation. Many new substations have an initial load requirement that can be satisfied with one outgoing line position on each of two substation transformers. Where such an installation can probably meet the load for a period of two years, the expansible design is quite worthwhile. Expansible double-bus switchgear permits the original installation to include only three power-circuit breakers, yet provides the bus tie and incoming breakers when additional outgoing positions are needed. The incoming line and respective outgoing line use a common breaker, as shown in Fig. 7. Three breaker positions are used in the original installation instead of five, as would otherwise be required. The resultant savings include carrying charges on two positions over the period of time used prior to expansion. These savings are slightly reduced by the cost of changing the relay and meter equipments at the time of expansion. The released panels are used in new expansible equipment.

The outgoing lines are terminated directly on the main busses. Direct breaker tripping from current transformers is used in the original assembly. Overcurrent and reclosing relays are installed on each incoming breaker. Overcurrent protection is also provided on the bus-tie breaker that becomes an outgoing line breaker whenever throwover occurs. Automatic throwover relaying is provided between each incoming and bus-tie breaker.

At the time of expansion, a bus shutdown is necessary. However, the transfer of load outside the substation is not difficult because of the relatively small load involved.

Magnetic Air Circuit Breakers. The previously described one-line diagrams can, of course, be duplicated using disconnecting-type magnetic air circuit breakers and metal-clad switchgear that is readily available from several manufacturers. The disconnecting feature of the draw-out and lift-type breakers eliminates the need of isolating disconnects on the bus tie and the incoming positions. For double-bus design, however, a second row of switchgear breaker housings is necessary, or the addition of disconnects on circuits is required.

Detroit Edison has purchased and installed certain air breaker switchgear with double-throw disconnects included in outgoing lines. To date, this arrangement has seemed preferable to double-row equipment from the standpoints of costs, operating ease, and over-all space requirements.

OPERATING CHARACTERISTICS

Substation Firm Rating. One advantage of the double-bus design as compared to the single-bus design is the higher "firm rating." The firm rating of a substation is defined in company nomenclature as the allowable load which an entire substation may carry. It is dependent upon the day-to-day and emergency ratings of the transformers and their associated unit equipment.

Day-to-day rating is the allowable load on unit equipment which may be carried during normal operating conditions through its particular recurring load cycles. Emergency rating is the allowable load on unit equipment during emergency conditions, such as the accidental loss of a transformer or radial feed. It is expected that a transformer and associated equipment will not operate under emergency load conditions for periods greater than 24 hours.

Firm calculations are made for both day-to-day and emergency conditions. The firm rating utilized is the lower of the two calculated values.

In a 2-transformer substation, the firm rating is almost invariably determined by the emergency rating of one unit, as each transformer provides throwover for the other, and the sum of the two day-to-day ratings

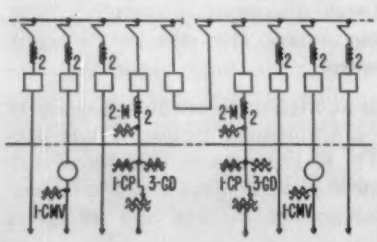


Fig. 6. One-line diagram, radial single bus.

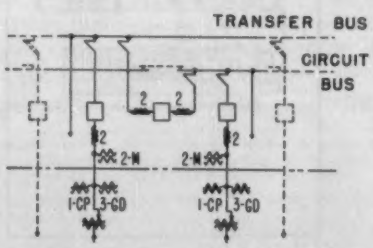


Fig. 7. One-line diagram, radial expansible double bus.

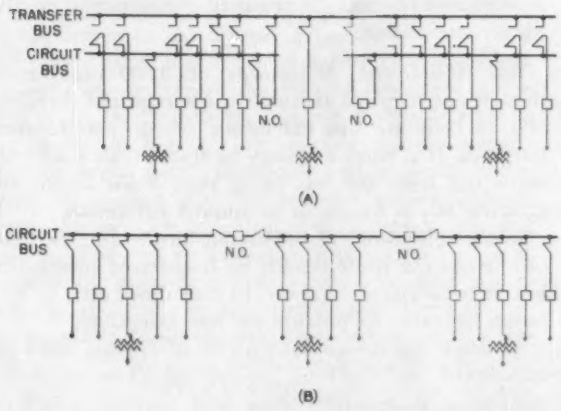


Fig. 8. One-line diagrams showing (A) radial double bus and (B) radial single bus.

(less a diversity factor) is usually greater than the emergency rating of one unit. The firm rating, therefore, is the same for both the single-bus and the double-bus type substations, because under either design each transformer provides throwover for the other. However, property is purchased and the substation is designed on the basis of ultimate installation of three or more transformers.

Fig. 8 shows one-line diagrams for both a 3-transformer double-bus substation and a 3-transformer single-bus substation. For either design each transformer normally serves the load of one bus, with the section (or tie) breaker normally open. In the event of loss of one transformer, the load of that bus is fed from another transformer through automatic breaker operation.

At the 3-transformer substation of the double-bus design, the load on the transfer bus is normally split in such a way that some load is served from positions opposite each of the two circuit busses. Inasmuch as it is feasible for an operator to balance load quickly on the two remaining busses in the event of loss of one transformer, both remaining transformers can effectively be placed in emergency. Thus, the substation firm rating can be calculated on the basis of two transformers at their emergency ratings. For a short time before an operator arrives, the load on one transformer may actually exceed the unit emergency rating. Since the time interval is very short, however, it is not considered as an overload on the unit equipment.

At the 3-transformer substation of the single-bus design, only one transformer can be utilized effectively to pick up the load of a second bus in the event of loss of one transformer. During this period, the other remaining transformer can be used to serve just one bus and, thus, can utilize only its day-to-day capability. Of course, additional load can be transferred to the second remaining unit by overhead jumpering. Overhead jumpering is relatively time consuming, however, and also may cause an overload on the distribution lines carrying the additional load. Therefore, this type of transfer is not considered practical in the determination of substation firm rating.

As a result of the difference in flexibility of operation the firm rating for a 3-transformer double-bus design substation is approximately 20% higher than for a single-bus design substation with comparable equipment.

Voltage Regulation. The relative ease of maintaining circuit voltage regulation is a second advantage of double-bus design substations.

Although line regulators are used in some instances, voltage control for 4,800-volt lines is normally accomplished in this system by bus regulation. Lines with similar characteristics with regard to size and occurrence of peak load, as well as length and size of overhead feeders and underground entrance cables, are grouped on one bus. The bus voltage is then maintained at the voltage most acceptable to the entire group of lines on that bus.

In areas such as the suburbs of Detroit, where load growth is rapid, load characteristics of a given area change rapidly also, with the result that lines which are best operated from one bus this year may be better operated from another bus next year. The growth factor is not often a problem in older established areas. However, expressway projects and slum clearance projects, such as are now in progress in the City of Detroit, are gradually making extensive changes in circuit area boundaries, and subsequently a change in voltage requirements.

Changes in circuit-voltage requirements seldom present a serious problem in double-bus substations. In most instances, disconnects can be switched on one or more circuits to obtain a suitable bus grouping.

The problem is more difficult and expensive at a single-bus substation. On some occasions, overhead feeders can be interchanged or load cutovers made to accomplish the necessary changes. More often, however, it is necessary to make cutovers on underground entrance cables. If difficulties arise due to cable routing, one or more sections of new cable may be required.

Bus Loading. Another operating advantage, similar in some respects to voltage regulation, is in the control of bus loading, which is normally maintained equal within practical limitations. Load cutovers or uneven load growth on the various 4,800-volt lines occasionally cause a definite unbalance in the normal load on the various substation transformers. In extreme cases, one transformer may be overloaded while another transformer or transformers are lightly loaded. If the load unbalance is severe enough to warrant revisions to bus grouping, the necessary revisions can usually be made at a double-bus substation by operating disconnects on one line, assuming voltage considerations are compatible.

Cable cutovers at the single-bus substations may be useful to interchange a relatively lightly loaded line with a heavily loaded line. On some occasions, though,

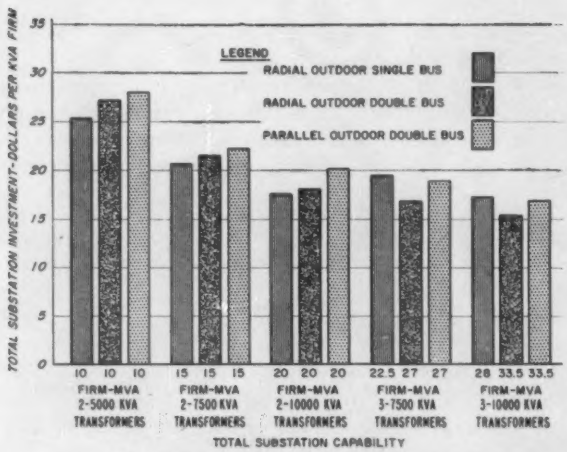


Fig. 9. Bar graph, outdoor substation costs.

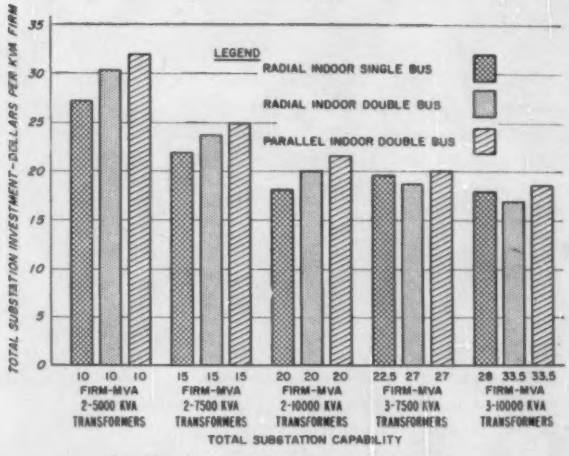


Fig. 10. Bar graph, indoor substation costs.

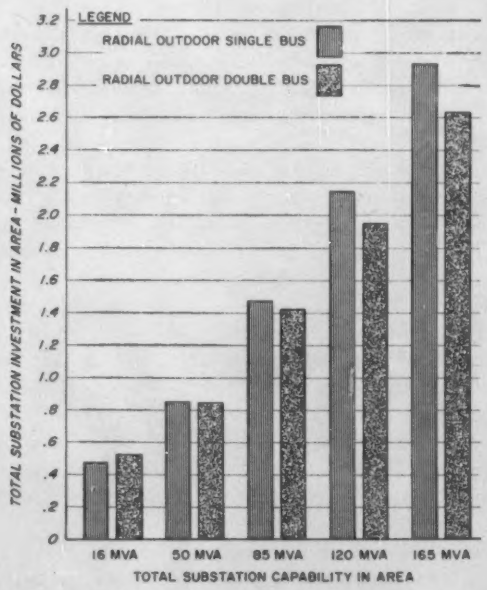


Fig. 11. Bar graph, area load costs.

a new position may be required prematurely on the lightly loaded bus.

Bus Shutdowns. Shutdowns of 4,800-volt busses, though not required frequently, are required occasionally to facilitate bus extensions or for maintenance purposes. It is then necessary to transfer all load normally fed from the bus being shut down to the remaining bus or busses, or to another substation.

In the substations of the double-bus design, the load of one bus can quite readily be transferred to another bus. It is necessary, however, to shut down each of two busses, in turn, to provide for bus extensions.

At single-bus design substations all circuits must be transferred by overhead jumpering. The overhead jumpering is relatively slow and requires excellent communication and teamwork between substation, system supervising, and overhead lines personnel. It also may cause an overload for the line or lines carrying the additional load. Since the shutdown time is so lengthy, it is difficult to complete any project involving a bus shutdown without having the shutdown extend into the daily peak-load period.

Throwover Lines. A typical distribution substation in this system has one 4,800-volt line, referred to as the "throwover" line, which carries no load under normal conditions, but is available for temporary transfer of load from each of the other 4,800-volt lines at that substation. The substation equipment, line entrance cable, and overhead portion of the throwover line have a load capability equal to or greater than any of the lines normally carrying load.

In a double-bus design substation, where bus shutdowns do not present a difficult operating problem, one throwover line is adequate for almost any contingency.

In single-bus substations, one throwover line is adequate when only one line is to be shut down; but when entire bus sections are taken out of service, it becomes desirable to have a throwover line installed on each bus or to provide a feed to the one throwover line from each bus. This is not a serious problem at the newer substations, since the initial load on a 4,800-volt line is likely to be considerably less than the capability of the line, and the doubling up of two lines normally carrying load is feasible. However, as the area load grows and economics dictate heavier loading on each line, throwover becomes an increasing problem. As the line and bus loads grow, the second throwover line becomes essential, and because of the necessity of carrying the load of more than one circuit, additional capability (such as doubling up of station entrance cable) may be required for each throwover line.

COST CONSIDERATIONS

Substation Costs. Several advantages inherent in double-bus switchgear have been discussed in preceding paragraphs. These advantages can be translated into dollar costs that establish the basis for preference of double-bus design. Figs. 9 and 10 illustrate graphically the cost per firm rating kva or substation capabil-

ity kva for various substation designs. These figures are applicable to the Detroit Edison substations that utilize switchgear that is assembled by Detroit Edison. The costs are determined for *current* labor and equipment costs. Fig. 9 includes outdoor designs similar to that shown in Fig. 2. The outdoor designs include masonry headquarter buildings and masonry transformer enclosures. Fig. 10 includes indoor designs, where the switchgear is installed within a masonry building. The cost per kva includes property, buildings, landscaping, switchgear, transformers, outdoor equipment, auxiliary equipment, and design. The first factors—property, buildings, and landscaping—include approximately 18% of the substation total cost. The costs stated in these charts are totally inclusive for the substation proper. They do not include subtransmission and distribution lines or operating and maintenance costs.

Figs. 9 and 10 show an obvious trend of reducing costs as the substation is increased in capability. However, they also show that when the firm rating exceeds 20 mva, the double-bus design becomes more economical. The double-bus design does not require throwover line positions merely to permit bus shutdowns. The double-bus design permits a higher capability with the same transformers where three or more units are installed because the loads may be balanced on remaining transformers.

Area Load Costs. Since the firm rating differs for 3-transformer substations of the single-bus and double-bus design, an economic comparison may be made by comparing costs to serve area loads as well as by comparing costs to serve loads of single substations.

Fig. 11 indicates total substation investment vs total substation firm capability for various stages of growth in a given area. The costs are substation construction costs only.

At the initial load period considered, the assumed installation included two 4-mva transformers at each of two substations. At this stage, the single-bus substation cost is about 8% less than that of the double-bus substations. As the load approaches 50 mva, where one substation of each design is assumed to have three transformers, the total investment is approximately equal. As the load increases, the double-bus design substations become more economical and a theoretical optimum is reached at 165 mva, at which point five 3-transformer substations of the double-bus design will serve the same load as six 3-transformer substations of the single-bus design. The cost differential at this stage is about 10%.

It is recognized that optimum conditions for even a relatively small area will seldom be attained. However, for any area, definite economies can be realized as soon as the load warrants the use of 3-transformer substations.

The cost figures shown in the graph indicate substation costs only. Additional subtransmission line facilities would be required for any fully developed single-bus substation area. These costs, though varying in different areas, would be substantial.

Operating Costs. The cost differential incurred in connection with voltage regulation, load balancing, bus shutdowns, and throwover lines, while not large relative to substation construction costs, is a recurring cost. The total becomes appreciable in a system with a large number of substations.

A typical cutover in which two distribution circuit cables are interchanged generally costs between $500 and $1,000. The frequency of such a cutover at a single-bus substation is approximately once a year per 10 feeder positions.

Bus shutdowns incur an additional expense of about $400 for the temporary overhead transfer of load of five load-carrying lines. A bus shutdown is normally required once per two years to facilitate substation switchgear additions.

Single-bus substations with total loads of 10,000 kva or more may require a second cable for each throwover line. The cost of doubling a typical throwover position feeder cable is $10,000.

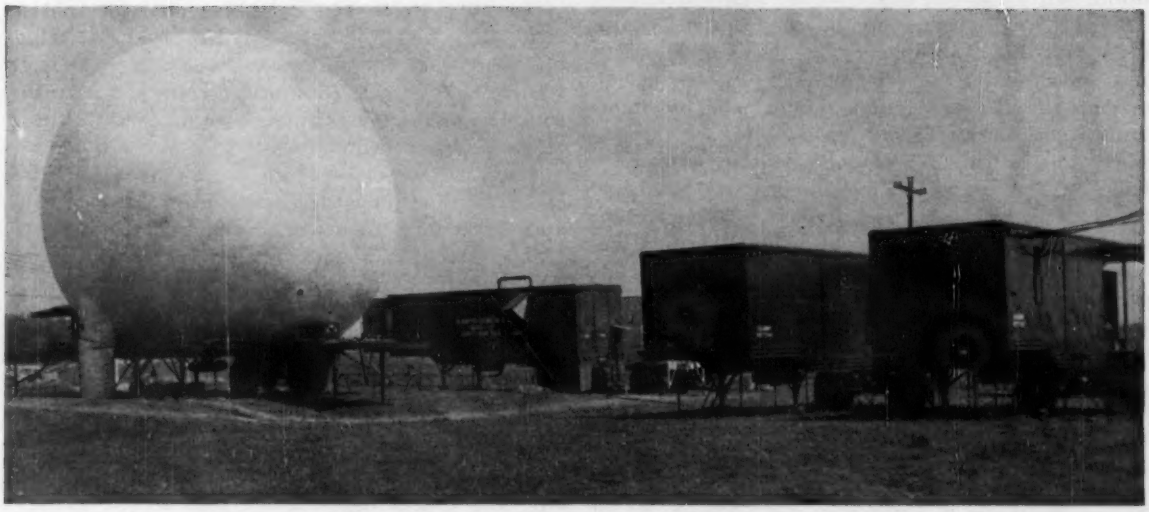
CONCLUSIONS

DOUBLE-BUS SWITCHGEAR as employed by the Detroit Edison system has resulted in definite cost savings and operating advantages when compared with single-bus switchgear design. These savings and operating advantages are of necessity based on current operating practices and distribution system design within the company. Methods of calculation of substation load capability, design and cost of switchgear, distribution and subtransmission design, and operating practices as outlined in this article may all vary widely with different operating companies. However, many evaluations of substation design and utilization discussed herein may be applicable to other systems.

The application of single-bus substations on the Detroit Edison system is currently confined to those areas where for geographical or other unusual conditions the load growth is very restricted.

Power for Turnpike

Stand-by electric power assures the smooth and continuous operation of the Dallas–Fort Worth Turnpike, which joins two of the principal cities in Texas. Each of the six toll plazas on the Turnpike, which is operated by the Texas Turnpike Authority, is equipped with a 10-kw electric plant from the Kohler Company of Kohler, Wis. The plants provide emergency power for floodlighting at toll plazas, emergency inside lights, and the operation of electric ticket machines. At one toll plaza, an electric plant was successfully used to provide emergency power for 18 hours during central power failure.



FRESCANAR—3-D DEFENSE

A "THREE-DIMENSIONAL" RADAR which detects airborne targets at extreme range and which, for the first time, simultaneously computes distance, bearing, and altitude, was unveiled recently by the U. S. Department of the Army at its Washington, D. C., headquarters.

Called Frescanar, the new radar, which was developed by Hughes Aircraft Company, Fullerton, Calif., is the eyes of "Missile Monitor," an Army air defense guided missile fire distribution system for mobile use with a field army.

The new radar and its electronic beam system is considered to be one of the most important advances made in electronic detection since the development of radar itself. Five basic advantages of the new 3-D system over conventional radars were cited:

Range performance. Frescanar concentrates all its available power in sharp pencil beams of energy flashing on and off in fan-shaped array in order to pinpoint targets that are at great distances with extreme accuracy.

Single antenna and one operator. Conventional defense detection systems need two or more radars and as many operators and master consoles to achieve similar results. Frescanar needs only one of each, thereby sharply reducing the weight, bulk, and number of personnel, thus making transportation with other Army field units much easier. The use of transistors has further decreased size and increased ruggedness for movement.

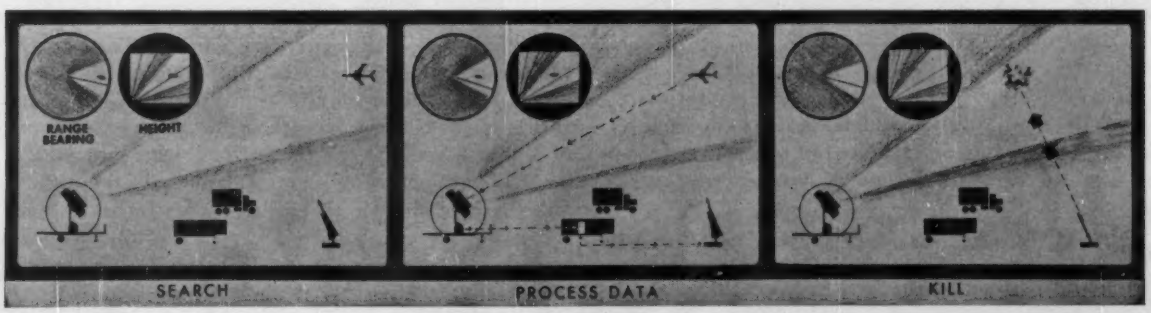
Triple function. Frescanar is considered to be so versatile that it computes the range, the bearing, and the altitude of the enemy airborne target all at the same time, thus giving standby forces a longer period of time in which to get ready for action.

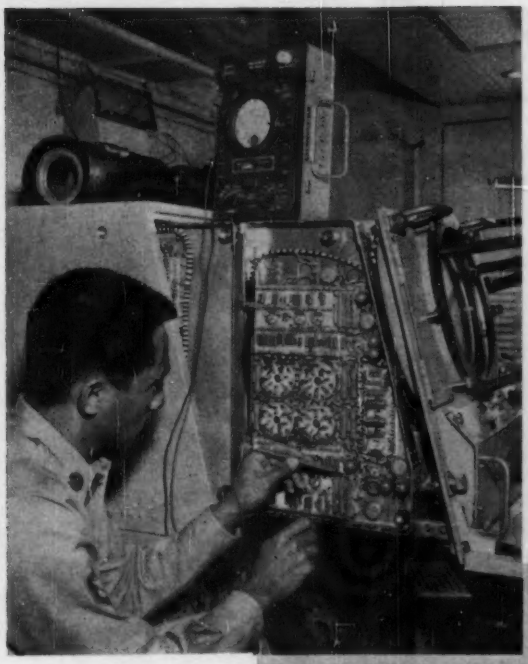
Greater speed. All three types of data—range, bearing, and altitude—are transmitted to these missile batteries, helping them to direct their missiles on the airborne targets much more rapidly.

Sees more targets clearer. There is an electronic beam that scans rapidly and, therefore, greatly increases the number of the targets which can be tracked at the same time. It also provides a better separation of closely spaced targets with a minimum of ground clutter. Targets are thus pinpointed much faster.

This Army system, which was developed by the Hughes Ground System Group, under a U. S. Army Signal Corps contract, consists of one equipment van, one power truck, and one antenna trailer. The equipment van houses all of the radar gear except the 15-ton antenna. The radar unit itself is evidence of joint service co-operation. The first developments, a U. S. Navy version of Hughes' Frescanar, originally was designed for use aboard ships.

In operational use of the Army radar, a radome of fabricated rubberized nylon—vulcanized to two layers of neoprene-coated fabric—weighing about 600 pounds, envelopes the operating antenna in order to protect the instrument from wind, snow, and ice. The radome is inflated by two air blowers and is kept inflated by a slight steady pressure from one of the blowers. The picture at the top of this page shows four U. S. Army Signal Corps trailers of the revolutionary new mobile





radar system, which has been designated *MPS-23*, and which simultaneously detects airborne targets in three dimensions. On the left is the plastic radome (white sphere) housing the 15-ton antenna which obtains information and then transmits it to the radar van situated on its right. The other two trailers, at the right, contain diesel generators which provide the power supply of the system while in the field. Only one of these units operates at a time; the other one is always on a standby basis.

The schematic panels seen at the bottom of the opposite page show the chronological steps in the operation of Frescanar. In the first panel, the pencil-beam antenna is scanning the skies at its extreme range for possible airborne targets. An "enemy" bomber is detected in the second panel and the antenna flashes the range and the bearing for display on the monitor scope, and the altitude on the other. Pertinent information then is relayed electronically almost instantaneously to those batteries which launch the missiles and score the "kill" (*third schematic panel*) while the antenna and the scopes continue to search and seek out other airborne enemy targets.

As an integral part of the Army's Missile Monitor, the new *MPS-23* radar operates somewhat in the manner that is described in the paragraphs which follow.

The radar antenna detects the airborne targets and three-dimensional information is fed electronically to the radar processing center which is the data-processing equipment and power supply. This unit converts the visual target data into digital form for information and sends it to a weapons monitoring center, battalion operations centers, and weapons battery terminal equipment—all part of the Missile Monitor.

The group commander stationed at the weapons monitoring center has complete information about aircraft that is in his area of operations and, thus, can select and assign targets to appropriate missile firing batteries. The battalion commander who is in charge of operating the battalion operations centers feeds the necessary pertinent information to the weapons complex in order to co-ordinate and distribute this fire power.

Various elements of the weapons battery terminal equipment, also known as the coder–decoder, are located at the missile firing centers. These units provide the information that is needed to fire the missiles, such as the Nike–Hercules, the Nike–Ajax, or the Hawk, at the airborne enemy targets detected by the three-dimensional *MPS-23* radar.

A slide-out check can be made of the entire console section of the *MPS-23* three-dimensional radar unit. Individual sectional units are easily maintained because they slide out on rollers. Specialist 4th Class George Real, seen in the picture that appears in the upper left-hand corner of the page, is using a voltmeter to check the resistors in the electronic circuit. The interior of the radar trailer itself contains dozens of "cards" with printed electric circuits that can be replaced instantly to keep the Army Signal Corps system in constant operation on a 24-hour basis.

With its side flaps completely open, one of the trailers that is the power truck (*photograph in center of page*) is ready to operate under field conditions as part of the Frescanar operation, with PFC Reuben Brown operating the controls of the console.

The two scopes seen in the photograph on the lower right-hand side of this page receive the target information from the radome-encased radar antenna. The scope on the left displays the target range as well as the bearing of the airborne enemy target. The scope on the right-hand side displays the altitude of the target under observation. The operators sitting at the units are identified by the Army as Specialist 5th Class Richard Ebert in the foreground, and Sgt. 1st Class Alfonso Mendez.

All of the various units are interconnected and can communicate with each other even though a portion of the system may be destroyed or inoperative. Thus, a fragmented system could still operate effectively in the field under fire.

ELECTRICAL ENGINEERING EDUCATION

AIEE in Villanova University

THE STUDENT BRANCH OF AIEE at Villanova University, Villanova, Pa., was authorized on October 20, 1933.

Instruction in Villanova's School of Engineering was begun in 1905 with the initiation of a civil engineering course. Courses in electrical, mechanical, and chemical engineering were added in the following 13 years.

Mendel Hall (*right*), erected in 1929, houses executive offices, classrooms, and laboratories for liberal arts, science, and engineering.

Iron Wire Exploration of Alternating or Constant Magnetic Fields

A. D. MOORE
FELLOW AIEE

CONSTANT MAGNETIC FIELDS have commonly been explored with iron filings, a small compass, or search coil together with fluxmeter. Alternating fields have been explored with search coils and by other means.

The use of a bit of iron wire to find the flux lines of an alternating field may be new. The writer has found no one who has heard of such a technique. It also may be used on constant fields. It enables one to lay out continuous flux lines with speed and simplicity.

Origin of the Technique

The author had been using a short piece of soft iron wire to give an approximate indication of the direction in space of an a-c field, at one particular location. Later, when trying out the wire in other parts of the field, it seemed that the wire was aligning itself with the field quite well, and that it might be developed as a field exploring device.

Explorer as a Straight Free Piece of Wire. The coil shown in Fig. 1 has 150 turns of No. 17 wire, in 8 layers. The winding space section is 0.4 by 1.17 inches, the inside diameter of the actual winding being 5.67 inches. A piece of plate glass supports a sheet of smooth paper in the plane of symmetry.

If a short piece of soft iron wire is laid on the paper, a field set up by the coil current will cause the wire to turn and align itself with the field. However, the free wire will often not remain in location: it will tend to be drawn across the flux lines and go to the coil itself.

Thus, the wire must be held to location in some manner.

Explorer with Loop at One End. The first form given an explorer was to bend a small closed loop at one end of a short straight piece of iron wire. A pencil point

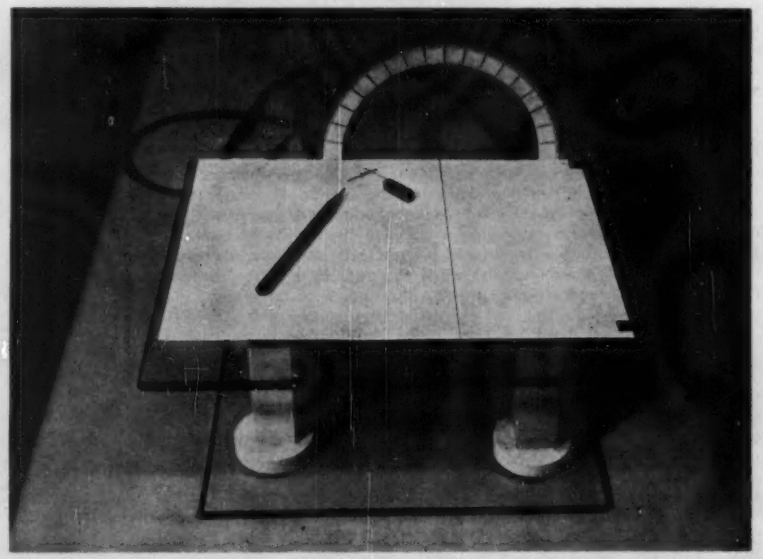


Fig. 1. Coil, arranged for explorer to lay out flux lines. Pencil points to the explorer. The handpiece for locating the explorer is also shown.

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was stuck down through the loop. The alternating 60-cycle field aligned the wire, and the field was thus explored. This design for the explorer demonstrated the feasibility of the technique, but there was a large error.

The source of the error can be seen by thinking of taking the free end of the wire, and deliberately moving it so that the wire is truly aligned with a short element of the flux line passing through its location. If the wire is now released (except for the looped end) the free end will swing slightly inward, toward the center of curvature of the flux line, because there is a crosswise force component of magnetic attraction acting on both ends. The result is that when the wire is stepped along and made to trace out a curve, this curve is constantly becoming shorter than the true flux line curve, and the error accumulates.

Explorer with Loop at Center. The error cited above is eliminated by letting the wire swing about its center. Both ends are now free to move. Each end tries to respond to the crosswise pull component. The effects cancel and, thus, the wire is allowed to align itself with the direction of the field.

The explorer used was made from 0.014-inch round soft iron wire, bought at a hardware store. It is 0.5 inches long.

A much larger explorer is shown in Fig. 1. The pencil points to it. This is merely a display demonstrator, made from a paper clip, and exhibited here because it would be large enough to show up in the photograph. Also seen is the handpiece which moves the explorer to position, and furnishes the shaft about which the explorer swings. This handpiece is made of a piece of brass, with a bent wire taped to it. The wire is No. 24 resistance wire which, like brass, is nonmagnetic. The handpiece wire is taped onto the top of the brass piece, extends horizontally out from it, and then bends vertically downward to form a shaft. The shaft goes down through the explorer loop and touches the paper.

The actual explorer was made by hand. An ample length of iron wire was tied firmly at one end. It was then pulled tight, and tightly wrapped once around a sewing needle, the needle being firmly anchored. A diameter was chosen on the tapered part of the needle, such as to give an inside loop diameter a little larger than the shaft. The excess was then cut off the wire, leaving equal lengths extending each way from the loop. The ends were pointed by rubbing them on a carborundum stone. Finally, to reduce friction with the paper, the explorer was pressed against a carborundum stone with the finger and rubbed along it to take off any roughness.

The upper part of Fig. 2 shows an enlarged scale drawing of the explorer.

Truing-Up Process

The explorer was mechanically "perfected" by localized bending and manipulating of shape until the extended arms were approximately aligned with the loop center, and also were approximately straight. But it could not be taken for granted that, therefore, it would behave correctly in the field.

The field itself was then called upon to help. The explorer was placed on the coil's axis line which was drawn on the paper. With an alternating field on, it was found that when one end of the explorer was accurately over the axis line, the other end was a little to one side. This error was eliminated, and the explorer was magnetically trued-up, by bending one arm or the other until both ends rested on the axis. It was then ready for business.

Mapping the Flux Lines

The technique calls for a sharply pointed pencil, prepared to make very small, accurate dots.

A start was made by making a dot at one of the inner points shown in Fig. 2. The explorer was moved by the handpiece, with field on, to where its inner end came to the starting dot. A dot was made at the other end. The explorer was moved along to start over again at the second dot, and a third dot was made at the other end—and so on.

For inner points, this coil required only 1 or 2 alternating amperes to get positive alignment. A coil current of 1 ampere gives a flux density in the neighborhood of point A, of roughly 60 lines or maxwells per square inch.

In the weak field where outer points were secured, coil currents of up to 16 or 20 amperes were needed. Even then, the explorer's job of overcoming friction with the paper sometimes needed help, in terms of tapping the handpiece, or the paper. This coil will carry only 4 amperes continuously, but high momentary currents can be carried to secure the outermost points.

For the curves shown, somewhere around 80 points were made. This work was done in a totalized time of only 10 or 15 minutes.

All of the points fall on or very close to their curves.

Accuracy

To investigate the accuracy achieved, an independent method of exploration was set up. Two search coils were arranged in

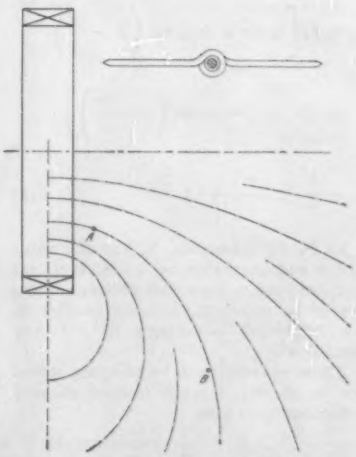

Fig. 2. Flux lines mapped by explorer.

the coil's field, these being coaxial, and each having one turn. The smaller, inner search coil had one side passing through the point A of the symmetry plane (Fig. 2). The outer, larger search coil's side passed through point B. The search coils were connected in series to a vacuum tube voltmeter, with their induced voltages opposed. With alternating current in the main coil to set up the field, search coil B was moved in or out axially until a null reading was secured. Points A and B would then fall on the same flux line.

Then, in using the explorer, the iron wire was started at point A, to lay out its version of a flux line. If this line passed through point B, there would be a precise check between the two methods. It is seen, Fig. 2, that the agreement is very close indeed.

It is pertinent to recall that in alternating current instruments of the moving-iron type, we rely on the fact that soft iron pieces in the instrument's alternating field are expected to perform reliably, and enable the instrument to have very good accuracy. Equally, we have a right to expect that if the explorer is magnetically trued-up with high accuracy, then its alignment with the field at any one location will be achieved with high accuracy. Beyond that, if the investigator does his work with adequate precision, he can expect to get good results.

Explorers longer than the one described here could be used for flux lines of gentle curvature. Shorter explorers could be used on sharply curved lines, to preserve accuracy.

Advantages of Alternating Field Exploration

Consider those cases in which the field to be explored has the same conformation, whether direct or alternating current is used in the coil or coils setting up the field, as when air-core coils are used, and no metal pieces are present that are heavy enough to have serious eddy current effects. The field, in actual use, might be constant. But it would be better to use the iron wire explorer with the alternating field.

The first advantage gained is the result of vibration. With an alternating field, vibratory forces act on the explorer, helping it to align by assisting in overcoming its friction on the paper.

The second advantage lies in its freedom from error because of residual magnetism. We can recall that in a moving-iron type ammeter, this error drops out when the ammeter measures alternating current; whereas, at least a small error may come in, if used on direct current. This is also true for the explorer.

Aside from these cases, there are cases where the field, in use, is affected by eddy currents in masses of metal. Here, the field must be explored using alternating current

in the coil or coils, and the iron wire explorer will do the job.

Exploring Constant Fields

The iron wire explorer is quite able to explore constant fields. With the vibratory effect of the alternating field absent, it becomes more necessary to help alignment by tapping the handpiece; or mechanical vibration of the paper support could be used.

Also, as previously brought out, there is the possibility of the explorer becoming somewhat magnetized, and bringing in residual error. This will probably be quite small, but no investigation has been made of its possible extent.

Increased Sensitivity

The simple explorer described can be greatly improved in sensitivity. The shaft-in-loop scheme would be replaced by a fine pivot bearing, such as is found in a good compass. The explorer would then respond accurately to far weaker fields.

Conclusion

Magnetic fields, either constant or alternating, may be explored with a short piece of iron wire made with a center bearing, it being used so that continuous flux lines are laid out. As investigated so far, the technique appears to promise high accuracy.

The extremely simple character of the exploring device, the simplicity of its use, and the fact that continuous flux lines result from the exploration, combine to recommend it, not only for application to real situations, but also for instructive experimental use in physics and electrical courses at any level where magnetic fields are studied.

Simplicity in 3-Phase System Circuit Conventions and Concepts

W. A. LEWIS
FELLOW AIEE

Part III

Substitution Variables: Direct-Axis, Quadrature-Axis, and Zero-Sequence Quantities

Equations 12 show the large number of trigonometric terms which enter the flux-linkage expressions, with the result that the differential equations representing generator behavior for various operating conditions will all have many terms with variable coefficients. The presence of such terms makes the solution of the differential equations extremely difficult. The solution may be facilitated by the substitution of other variables which may eliminate or at least minimize the number of variable coefficients. The most effective of these are the direct-axis and quadrature-axis quantities introduced by R. H. Park.[4] However, certain facets of these quantities as he used them have led to some difficulties, and one of the purposes of this article is to show that some changes in the definitions of these quantities would improve the situation, both in utility and simplicity.

Using a method similar to Park's, but with provision for later adjustment, let us define the direct-axis, quadrature-axis, and zero-sequence currents by

$$i_d = k_d \left[i_a \cos \sigma + i_b \cos \left(\sigma - \frac{2\pi}{3} \right) + i_c \cos \left(\sigma - \frac{4\pi}{3} \right) \right]$$

$$i_q = k_q \left[i_a \sin \sigma + i_b \sin \left(\sigma - \frac{2\pi}{3} \right) + i_c \sin \left(\sigma - \frac{4\pi}{3} \right) \right]$$

$$i_0 = \frac{1}{3} (i_a + i_b + i_c) \qquad (13)$$

In Park's definitions, k_d had the value $+2/3$ and k_q the value $-2/3$. It is our purpose here to show that different values are to be preferred, with no sacrifice in the important advantages of the new variables.

These equations can be uniquely solved for the phase currents, in terms of the new components, to give

$$i_a = \frac{2}{3k_d} i_d \cos \sigma + \frac{2}{3k_q} i_q \sin \sigma + i_0$$

$$i_b = \frac{2}{3k_d} i_d \cos \left(\sigma - \frac{2\pi}{3} \right) + \frac{2}{3k_q} i_q \sin \left(\sigma - \frac{2\pi}{3} \right) + i_0$$

$$i_c = \frac{2}{3k_d} i_d \cos \left(\sigma - \frac{4\pi}{3} \right) + \frac{2}{3k_q} i_q \sin \left(\sigma - \frac{4\pi}{3} \right) + i_0 \qquad (14)$$

Exactly analagous expressions are used for flux linkages and for voltages, the corresponding symbols being substituted for the current symbols in each case.

If the phase currents of equations 14 are substituted in the flux-linkage equations 12, and the result is substituted in the set of equations analagous to equations 13, except for flux linkages instead of currents, the result will be to express the new flux-linkage components in terms of the corresponding new current components. One of these equations will be, for the direct-axis component only,

$$\lambda_{gd} = \left(L_{ss} + L_{ms} + \frac{3}{2} L_{sv} \right) i_d + \frac{3}{2} k_d L_{afM} i_f \qquad (15)$$

If, now, i_d from the first of equations 13 is substituted in the last of equations 12, the flux linkages of the field may be expressed

$$\lambda_f = \frac{L_{afM}}{k_d} i_d + L_{ff} i_f \qquad (16)$$

It is to be noted that these equations are relatively very simple, and contain only two of the current variables. Also, they are similar in form to the expressions for the flux linkages of two static coupled circuits, with constant self-inductances and mutual inductances. However, for such circuits the mutual inductances would be reciprocal, that is, the mutual inductance to the first circuit from the second would be the same as from the second circuit to the first. This is not true in equations 15 and 16, unless k_d is given a special value. Because having this requirement satisfied is very beneficial to further analysis, we may select k_d so that this requirement is fulfilled. Then

$$\frac{3}{2} k_d L_{afM} = \frac{L_{afM}}{k_d}$$

$$k_d^2 = \frac{2}{3}$$

$$k_d = \pm \sqrt{\frac{2}{3}} \qquad (17)$$

It may be noted that the value of k_d may be either plus or minus, again a question of whether a mutual inductance should be set up as positive or negative. From equations 14 it can be seen that

Part III of a 3-part article recommended for publication by the AIEE Educational Publications Committee.

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when i_d is positive, the part of i_a resulting from i_d will be positive where σ is zero, or lies between $-\pi/2$ and $\pi/2$, if k_d is positive. Thus, simplicity and consistency would suggest that the positive sign be chosen.

Furthermore, it has already been shown that the field current and the armature current are mutually aiding when the current leads the no-load terminal voltage. An expression for i_a for zero power factor leading is given by equation 10. If this and the corresponding values of the i_b and i_c are substituted in the first of equations 13, i_d will be positive if k_d is. The substitution of positive values of both i_f and i_d in equations 15 and 16 shows that, for these same conditions, i_d and i_f are mutually aiding if k_d is positive. Thus, the direct-axis flux linkages are positive when the armature current aids the field. This is consistent with all the previous choices and provides a major reason for choosing k_d as positive.

For the example used, there are no circuits on the rotor symmetrical about an axis 90 degrees or $\pi/2$ radians ahead or behind the axis of the field circuit. However, in many machines, there are damper circuits in this position. Wherever one is included, an analysis exactly similar to that relating the flux linkages of the field and direct-axis circuit would be applicable to the damper circuit in this other axis and the quadrature-axis armature circuit, replacing the actual armature circuits, and the result would show the desirability of selecting

$$k_q^2 = \frac{2}{3}$$

$$k_q = \pm\sqrt{\frac{2}{3}} \qquad (18)$$

Again, a choice must be made as to whether the sign of k_q is to be plus or minus. However, in this case there is no previously established normal direction for current in the quadrature axis, because there is no current in the damper circuits under normal steady-state conditions. Therefore, the choice must be based upon considerations other than those used in selecting the sign of k_d.

For positive power flowing to a load on the generator, using the conventions previously adopted, the current should be positive at the instant the voltage reaches its positive maximum. For unity power factor, determined with regard to the no-load voltage, the current in phase a would have the same variation with σ as does the no-load voltage. Comparison with equation 9 shows that the current would then have the form

$$i_a = \sqrt{2}\,|I_a| \sin\sigma \qquad (19)$$

with corresponding expressions for the other two phases given by

$$i_b = \sqrt{2}\,|I_a| \sin\left(\sigma - \frac{2\pi}{3}\right)$$

$$i_c = \sqrt{2}\,|I_a| \sin\left(\sigma - \frac{4\pi}{3}\right) \qquad (20)$$

These currents form a balanced 3-phase set, having equal amplitude and being equally displaced in phase.

Substitution of these currents in equations 13 gives

$$i_d = 0 = i_0$$

$$i_q = \frac{3}{\sqrt{2}}\, k_q\, |I_a| \qquad (21)$$

Thus, it is seen that i_q will have the same sign as k_q for this condition. Since i_d and i_0 are zero, it is evident that i_q represents the normal power component of current, and it is hardly logical to select it as anything but positive. For this result, $k_q = +\sqrt{2/3}$, and i_q becomes

$$i_q = \sqrt{3}\,|I_a| \qquad (22)$$

The simplest and most logical choice at each opportunity, therefore, leads to the selection of k_d and k_q as both positive and both equal to $\sqrt{2/3}$, instead of $+2/3$ for k_d and $-2/3$ for k_q, as used by Park.

From the foregoing, it may be seen that i_d is that component of the armature current which acts to magnetize the field along the same axis as the field winding itself does. For normal 3-phase balanced currents, both i_d and i_q are constants, representing the rotating field resulting from the joint action of the three phase currents. For currents which lead the no-load voltage by 90 degrees or $\pi/2$ radians, i_d is a positive maximum and i_q is zero. Conversely, if the current lags by the same angle, i_d is a negative maximum. If the current is in phase with the no-load voltage, i_q is a positive maximum and i_d is zero. Thus, i_q tends to magnetize the rotor in a direction 90 degrees from the axis of the field.

It is logical, therefore, to identify the two axes of the field by the same terminology. Then the axis of the field winding is called the direct axis of the rotor, and the axis at right angles is called the quadrature axis. The positive direction of each of these axes would be the direction it is magnetized by the positive current component having the same name. Under the conventions assumed, the positive direction along the direct axis is the direction of magnetization by the field current and would be in the direction indicated by

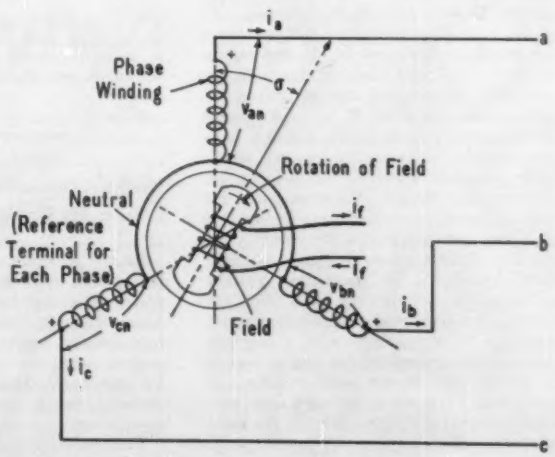

Fig. 3. Synchronous machine circuit diagram.

Electrical Engineering Education

the arrow along the axis of the field in Fig. 3. It has already been shown that positive i_d corresponds to zero power factor leading current and positive i_q to unity power factor current, which reaches its maximum 90 degrees or $\pi/2$ radians later. Therefore, the positive direction of magnetization along the quadrature axis of the rotor is 90 degrees behind the direct axis. The relations are shown in Fig. 4.

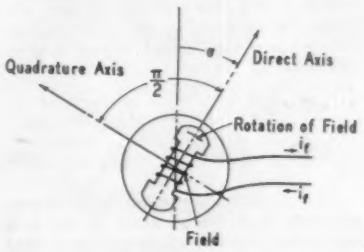

Fig. 4. Conventions regarding rotor axes (quadrature axis behind direct axis).

This result, also, is at variance with Park's choice, inasmuch as he selected the positive quadrature axis to lead the positive direct axis by $\pi/2$ radians, instead of to lag by the same angle. Actually, this difference is the consequence of selecting k_d and k_q to have the same signs in this analysis, instead of opposite signs. Conversely, the positive directions of the axes could have been chosen first, and the choice would have given a reference direction to current in a quadrature-axis damper circuit, from which the choice of sign for k_q would follow. Thus, either the relative positions of the axes or the relative signs of k_d and k_q would be chosen first, but one involves the other.

The choice of k_d and k_q in the equation

Electrical Engineering Education

for current implies, of course, that the same values will be used in the corresponding equations for voltage. The choice of the plus sign for k_q is also desirable from the standpoint of its effect on the voltage equation. The voltage of phase a at no load is given by equation 9, with similar equations for the voltages of the other phases. If $d\sigma/dt$ is given the constant value ω, the direct-axis, quadrature-axis, and zero-sequence voltages, obtained by substituting the three no-load voltages in voltage equations analogous to equations 13, are

$$v_d = 0 = v_0$$

$$v_q = \frac{3}{2} k_q \omega L_{af M} i_f \qquad (23)$$

Again, all else being equal, it is entirely desirable that the quantity in the new components which represents the no-load voltage of the generator under normal conditions should be positive. This will result, if conventions previously recommended are followed, only if k_q is plus. If k_q is $+\sqrt{2/3}$, as recommended earlier in this section, v_q becomes

$$v_q = \sqrt{\frac{3}{2}}\ \omega L_{af M} i_f \qquad (24)$$

The expression $\omega L_{af M} i_f$ corresponds to the crest of a sine wave of armature voltage in each phase. If the rms value is denoted by $|V_{an(NL)}|$, the value of v_q, of course, becomes

$$v_q = \sqrt{3}\ |V_{an(NL)}| \qquad (25)$$

for the conditions considered. This result is consistent with equation 22, and both v_q and i_q are positive for normal generator action at unity power factor, when k_q is positive.

The preceding discussion in this section applies specifically to synchronous generators. If, however, the recommendations of the preceding section are followed that the reference directions of all currents be reversed (with no change in the reference polarities of voltages), the equations for substitution variables, i_d, i_q, and i_0, and the corresponding equations for flux linkages and for voltages, are equally applicable to motor analysis, without change. The use of equations like equation 4 instead of equation 3 would reverse the sign of voltages in relation to the corresponding flux linkages, but the provision discussed previously (in the section devoted to "desirable conventions") that the field current of a synchronous motor in normal operation be expected to have a negative value would compensate for this change so far as the sign of the no-load voltage is concerned. Thus, no undesirable situations would result other than that of the field current itself.

Summary and Recommendations

The preceding analysis has shown that the conventions of circuit analysis are closely related, and that if a comprehensive analysis is built up from basic principles, simplicity and consistency will indicate the most desirable choice of convention. As a result of the preceding discussion, the following recommendations are offered:

1. When double subscripts are applied to voltages, the first subscript denote the terminal of higher (positive) voltage when the numerical value of the voltage is positive.
2. The reference direction of flux linkage be chosen so that positive current (in the reference direction) will produce positice flux linkage in its own circuit.
3. The formulation of Lenz's Law indicate the conventions regarding current and flux-linkage direction and voltage polarity, and have a plus or minus sign assigned according to the conventions assumed.
4. The standard direction of rotation of a rotating field in a synchronous generator or motor general diagrammatic representation be chosen as clockwise, so that the motion of the armature, relative to the field, will be counterclockwise.
5. The positive direction of the quadrature axis in a synchronous machine be chosen to lag the positive direction of the direct axis by $\pi/2$ electrical radians or 90 electrical degrees, in the direction of rotation, rather than lead, as originally selected by Park in defining these quantities.
6. The k_d and k_q, as used in equations 13 to define direct-axis and quadrature-axis armature quantities, both be assigned the value $+\sqrt{2/3}$, instead of $+2/3$ and $-2/3$, respectively, as used by Park in defining these quantities.

The use of a simple and consistent set of conventions, such as those suggested, will greatly facilitate understanding of polyphase systems and machine theory. The suggestions made are believed to be the simplest and most convenient, and to represent an improvement over conventions now in use by a number of authors.

Reference

4. Definition of an Ideal Synchronous Machine and Formula for the Armature Flux Linkages, R. H. Park. *General Electric Review*, Schenectady, N.Y., vol. 31, 1928, pp. 332-34.

Nuclear Technology Courses for Foreign Students

Details of three advanced-study courses in nuclear technology which the United States is establishing in existing U. S. Atomic Energy Commission (AEC) facilities for the students of friendly foreign nations were presented to delegates during the 2nd International Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland.

The courses are: Reactor Hazards Evaluation, Reactor Supervision, and Radiochemical and Counting Procedures.

Reactor Hazards Evaluation and Reactor Supervision will be conducted at the AEC's Oak Ridge National Laboratory (ORNL) at Oak Ridge, Tenn., beginning on February 2, 1959.

Radiochemical and Counting Procedures will be given at the New York Health and Safety Laboratory of the AEC in New York, N. Y. The first class was scheduled for October 6, 1958, and a second class will follow on January 12, 1959.

The sessions at ORNL will be given once each year. Hazards Evaluation training will be of 12 months duration while Reactor Supervision studies will continue for 9 months, with accommodations for about 10 students in each class. Radiochemical and Counting Procedures will require 6 weeks of study, will be given 4 times each year and will accommodate 6 students in each class.

This represents another step in the Atoms-for-Peace program inaugurated by Pres. Eisenhower in 1953 to extend to people throughout the world the benefits derived from the peaceful uses of atomic energy.

The purposes of Reactor Operations Supervision is to prepare engineers or scientists to superintend efficiently the operation of research or power reactors and to ensure the safety of the people around them. The program will cover reactor operations, health physics, and instrumentation and control, and will emphasize the supervisor's responsibility and the technical competence required for operating a reactor.

The Reactor Hazards Evaluation course is designed to help the student develop his ability to evaluate the whole range of hazards that might be encountered in reactor operations, including those associated with criticality. Lectures on hazards and their evaluation from many different points of view will be given by United States experts who have specialized in these aspects of reactor development.

The course in Radiochemical and Counting Procedures at the New York Health and Safety Laboratory will consist of lectures, discussions, laboratory work, and solutions of actual problems.

Engineering Physics Program at Lowell Tech

A 4-year course in engineering physics leading to the bachelor of science degree was instituted at Lowell Technological Institute, Lowell, Mass., in September, according to Dr. M. J. Lydon, president. The program, approved by the board of trustees, was developed to meet the demands of industry, education, and Government for people intensively trained in physics and mathematics to help solve some of the problems of the current crisis in science.

Dr. C. R. Mingins, chairman of the Division of Engineering and head of the department of physics and mathematics, who heads the new course, said in commenting upon the program that students planning to major in engineering physics in preparation for careers in research or college

teaching should have an excellent understanding of basic matters in science and the ability to make sound judgments on these matters.

The course brings to a total of 11 the number of undergraduate programs of study offered at the 63-year old coeducational engineering college. Other B.S. degree programs are presented in chemistry, textile chemistry, and textile technology, and in electronic, general, leather, nuclear, paper, plastics, and textile engineering. Lowell Tech also offers the M.S. degree in chemistry and textile chemistry and in electronic, leather, paper, and textile engineering as well as the Ph.D. degree in chemistry.

NYU and Curtiss-Wright To Conduct Solar Research

The Curtiss-Wright Corporation and New York University (NYU) have announced joint and separate programs for research, development, and practical application of solar energy to be carried out at the Princeton Division of Curtiss-Wright (C-W), Princeton, N. J.

All three programs will be under the direction of an internationally known solar scientist, Dr. Maria Telkes.

The announcement of the new broad-scale projects was made by R. T. Hurley, chairman and president of C-W, and Dr. J. R. Ragazzini, dean of the NYU College of Engineering.

Curtiss-Wright, Mr. Hurley said, is entering the field of solar energy with immediate emphasis on the development and production of commercially saleable solar products, based upon existing patents, knowledge, and needs.

Dr. Ragazzini said: "It is anticipated that New York University's participation in the joint program will generate many new and basic discoveries in the field of solar energy which will be of benefit to homes and industries throughout the world."

The NYU program is a co-operative industry–university project. It consists of the establishment at Princeton of the NYU Solar Research Laboratory to provide a base for teaching, research, and the dissemination of knowledge in the field of solar energy. Dr. Telkes will direct the Laboratory with the status of a research professor. C-W, among other companies, will provide grants for research projects, as well as a building to house the NYU Solar Research Laboratory staff of scientists and technicians. It will make other facilities available, too.

Co-operation with the business firm in solar energy will be only one phase of NYU's solar program. The NYU Solar Research Laboratory will limit its activities to academic type research and will not develop properties and patent rights for the University. It will, however, continue to conduct separate research and development programs with commercial organizations and Government agencies.

A complete Sun Court and Solar Laboratory is now under construction by Curtiss-Wright at its Princeton Division where solar products will be produced. The Sun Court includes a solar heated house and a solar heated swimming pool, solar furnaces, solar batteries, solar stills, solar driers, solar cooking equipment, solar radios, and solar food processing equipment.

"Our basic business is converting energy into useable power," Mr. Hurley said. "The energy from the sun's rays offers the greatest potential source of power for the improvement of standards of living known to man. The amount of sunshine falling on one acre in a year in the temperate New York City area is the equivalent of the energy from 850 tons of coal which has an approximate value of $8,500. In desert and tropical areas it is even higher. An acre-year of sunshine in Reno, Nev., for example, equals 1,300 tons of coal or $13,000.

"The standards of living of millions of people in parts of the world where fresh water and fuel is in short supply can be improved by harnessing the power of this tremendous source of energy."

Dr. Telkes, who will direct both the C-W Solar Radiation program and the NYU Solar Research Laboratory, is noted for the emphasis she has placed on putting the sun's rays to practical use. She has been in charge of solar energy experiments at NYU since 1953. In her new dual capacity, she will have the status of a research professor of the University.

For 14 years prior to joining NYU Dr. Telkes was associated with the Solar Energy Conversion Project at Massachusetts Institute of Technology. During World War II, working in co-operation with the U. S. Office of Scientific Research and Development, she developed the solar still, used by the U. S. Air Force on life rafts, which converted salt sea water into sweet fresh water.

Dr. Telkes holds many patents for solar heating devices, solar stills, solar driers and has done extensive work in thermoelectric generators for the conversion of solar energy into electric power. A graduate of the University of Budapest. Dr. Telkes holds a Ph.D. in physical chemistry.

String Models Effective as Visual Aids in Education

The Educational Division of Industrial Research Laboratories, Inc., offers a diversified selection of string models in response to a growing demand for effective visual aids in instruction.

Of interest to the teacher of mathematics, engineering, engineering drawing, descriptive geometry, and physics, as well as to the designer and draftsman in industry and architecture, these carefully designed and precision-made models are manufactured of plexiglass and strung with elastic nylon. They are unique insofar as they are the only type that can demonstrate the mathematical concept that straight-line generators produce certain surfaces such as the quartic, hyperbolic paraboloid, etc.

For further information, write to: Industrial Research Laboratories, Inc., Educational Division, P.O. Box 471, Hempstead, N. Y.

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Syracuse University Orders Reactor Simulator

The fifth United States school to order a nuclear simulator for training purposes in 1958 is Syracuse University, an announcement from Minneapolis-Honeywell Regulator Company stated.

The simulator artificially recreates the operational characteristics of a real reactor with use of an electronic computer circuit. The automatic control system is the same as that on power and research reactors.

Schools that have purchased the simulator are the Universities of West Virginia, Minnesota, Oklahoma, and Wayne State. The University of Toronto also has installed the Honeywell simulator. Basic price of the simulator is $15,500.

Antenna Research at Ohio State University

A group of Ohio State University engineers has completed initial research on an antenna for an instrument landing system which soon may enable airplanes to land in bad weather without verbal instructions from the airport.

Using the new system, a plane would pick up "glide path" signals about five miles from its destination. These signals give vertical guidance to the pilot who is flying on instruments, providing the direction necessary to bring in the plane and set it down on the runway.

Research on the project was carried out under the direction of R. H. McFarland, Ohio State Antenna Laboratory research associate.

The glide path system currently in use at major airports is known as the "null reference" type. Employing a 25-foot antenna structure, it brings the plane to within only 30 feet of the point of touchdown. Because of its height, this type of antenna can be located only alongside the runway.

At the request of the Civil Aeronautics Administration (CAA), Mr. McFarland began research at Ohio State in Spring 1957 on a type of antenna to be placed in the runway, flush with the surface. An antenna of this type would radiate a signal to direct a plane all the way to the point of touchdown in "zero-zero" weather.

After nearly 2 years of experiments at the University's Antenna Laboratory, two trough-shaped antennas were built and filled with a nonconductive substance. Common cattle salt was the nonconductive material used in the two 20-foot-long test antennas.

Late last Spring, they were set in a CAA runway south of Indianapolis, Ind., and covered with plastic lids. They were

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placed end-to-end, but 160 feet apart. McFarland said the path formed by the two antennas was test flown "with very good results."

At least two such antennas are required to form a glide path. But, no less than six would be used in the construction of an actual glide path installation for daily use.

The path climbs at a 3-degree angle and widens as it leaves the runway. About five miles from the point of touchdown, where it normally is picked up by an incoming aircraft, the path is about three-quarters of a mile wide and some 1,500 feet above the earth.

McFarland said that when additional research is completed by the CAA on a "zero-zero" landing system, using the Ohio State antennas, installations may begin at major airports throughout the nation.

Staff Fellowships At Hughes Aircraft

Nine outstanding scientists and engineers of Hughes Aircraft Company have been awarded Hughes Staff Doctoral Fellowships enabling them to study for doctor's degrees, it was announced by Dr. A. V. Haeff, company vice-president.

The fellowships provide a minimum stipend of $1,500 a year plus cost of tuition, fees, and textbooks. Winners will hold their regular full-time jobs at Hughes during summer months and those attending nearby universities will work one day a week during the academic year.

The staff fellowships, inaugurated this year, are limited to Hughes employees. Another program in its 10th year—the Howard Hughes Fellowships—is open to nonemployees and currently has 15 studying for Ph.D degrees.

The staff doctoral plan is the latest of many comprehensive education programs long in effect at Hughes Aircraft.

The fellowship winners are D. B. Donalson, E. H. Erath, R. L. Forward, R. W. Hougardy, Maier Margolis, J. E. Mercereau, L. A. Rondinelli, F. L. Vernon, Jr., and J. K. Yakura. All are residents of the Los Angeles area.

Ground-Breaking Ceremonies for Engineering Building at Clemson

Ground-breaking ceremonies for the $1.175 million S. B. Earle Chemical Engineering Building—largest single gift ever received by Clemson College—were held September 27 on the building site.

The building, which will be substantially completed by September 1959, was presented to the College April 12 as a gift, the second in five years, of the Olin Foundation of Minneapolis, Minn.

Olin Hall, which houses the department of ceramic engineering, was presented in 1953 at a cost, including complete modern equipment, of $600,000.

Honored guests were Dr. Earle; Dr. C. L. Horn, president of Olin Foundation; and Dr. J. O. Wynn, vice-president. Joining them in the traditional earth turning were acting Clemson College President R. C. Edwards and Frank Jervey

Dr. Horn, of Minneapolis, and Dr. Wynn, of New York, N.Y., spoke on the program, and Dr. F. M. Kinard, dean of the College, briefly recounted the history of engineering growth at Clemson. R. M. Cooper, of Wisacky, president of the board of trustees, presided.

Approximately 200 invited guests attended the ceremonies, followed by a luncheon in the college dining hall and the Clemson–North Carolina football game in Memorial Stadium.

The new building site is located opposite the recently completed Civil Engineering and Architecture Buildings.

Dr. Walker Receives Award from Department of the Navy

Dr. E. A. Walker (F '47), president of the Pennsylvania State University, was cited at Washington, D.C., by the Department of the Navy for his "outstanding contributions . . . in the fields of scientific research and development."

The department's Distinguished Public Service Award was conferred on Dr. Walker by Admiral Arleigh Burke, Chief of Naval Operations, in the name of the Secretary of the Navy. The ceremony formally closed Dr. Walker's 2-year term as chairman of the Committee on Undersea Warfare of the National Academy of Sciences–National Research Council.

Dr. Walker, who will continue to serve as a member of the committee, was praised in the citation for his "leadership . . . inspiration . . . keen insight . . . and advice" in highly complex long-range research and warfare.

The award is the highest of three conferred on civilians by the Department of the Navy.

Engineering Appointments at Northwestern University

Appointment of five new members of the engineering faculty has been announced by Dean H. B. Gotaas of the Northwestern University Technological Institute.

Joining the electrical engineering faculty is Assoc. Prof. M. E. Brodwin, who has been a member of the staff at the Johns Hopkins University radiation laboratory, Baltimore, Md. He holds a bachelor's degree in electrical engineering from the University of Nebraska and master's and doctoral degrees from Johns Hopkins.

Asst. Prof. D. S. Gage, a native of Evanston, Ill., also has been appointed to the electrical engineering faculty. He received a bachelor's degree at Northwestern in 1953 and master's and doctoral degrees at Stanford University. Prof. Gage was a lecturer at Northwestern for several months prior to his appointment for the 1958-59 academic year.

Asst. Prof. Joshua Dranoff, who received a doctoral degree earlier this year at Princeton University, has been appointed to the chemical engineering department. He was graduated with highest honors from Yale University in 1954 and received a master's degree at Princeton in 1956.

Two assistant professors who will become members of the civil engineering department faculty are: John Dundurs and M. J. Stewart.

NSF Graduate and Postdoctoral Fellowships

The National Academy of Sciences–National Research Council will again assist the National Science Foundation (NSF) with its eighth regular predoctoral and postdoctoral fellowship programs which have recently been announced by the NSF. The NSF plans to award approximately 1,000 graduate and 200 postdoctoral fellowships in these two programs for scientific study during the 1959-60 academic year.

The evaluation of each candidate's application is made by the Academy-Research Council selection panels and boards. The NSF will make the final selection of fellows and will announce the awards on March 15, 1959.

These fellowships are open only to citizens of the United States and are awarded solely on the basis of ability. The NSF has announced that " fellowships will be awarded in the mathematical, physical, medical, biological, and engineering sciences, including anthropology, psychology (excluding clinical psychology), and from the following social sciences, where they conform to accepted standards of scientific inquiry by fulfilling the requirements of the basic scientific method as to objectivity, verifiability, and generality: geography, mathematical economics, econometrics, demography, information and communication theory, experimental and quantitative sociology, and the history and philosophy of science. Also included are interdisciplinary fields which are comprised of overlapping fields among two or more sciences."

Graduate fellowships are available to those who are working toward the master's or doctoral degrees in the first, intermediate, or terminal year of graduate study. College seniors who expect to receive a baccalaureate degree during the 1958-59 academic year are also eligible to apply. Postdoctoral fellowships are available to individuals who, as of the beginning of their fellowship tenure, have a Ph.D. in one of the fields listed or who have had research training and experience equivalent to that represented by such a degree. In addition, holders of the M.D., D.D.S., or D.V.M. degree, who wish to obtain further training for a career in research, are eligible provided they can present an acceptable plan of study and

research. "Awards are not made to individuals to pursue a course of study designed to prepare them further for careers in medical practice and comparable fields; however, applications will be accepted from those who intend to obtain further training in one of the medical sciences directed toward a career in research."

All applicants for graduate (predoctoral) awards will be required to take an examination designed to test scientific aptitude and achievement. This examination, administered by the Educational Testing Service, will be given on January 19, 1959, at designated centers throughout the United States and certain foreign countries.

The annual stipends for graduate fellows are as follows: $1,800 for the first year; $2,000 for the intermediate year; and $2,200 for the terminal year. The annual stipend for postdoctoral fellows is $4,500. Dependency allowances will be made to married fellows. Tuition, laboratory fees, and limited travel allowances will also be provided.

Further information and application materials may be obtained from the Fellowship Office, National Academy of Sciences–National Research Council, 2101 Constitution Avenue, N.W., Washington 25, D.C. The deadline for the receipt of applications for regular postdoctoral fellowships is December 22, 1958, and for graduate fellowships, January 5, 1959.

Nation-Wide Study of Co-operative Education

The first nation-wide "Study of Co-operative Education" in American colleges and universities was announced recently in New York, N.Y., by Dr. R. W. Tyler, chairman of the Study Committee on Co-operative Education, and director of the Center for Advanced Study in the Behavioral Sciences, Palo Alto, Calif.

The project is supported by a grant of $95,000 from the Fund for the Advancement of Education, a subsidiary of the Ford Foundation.

Approximately 60 colleges and universities now have programs of co-operative education for some or all of their students. Under the co-operative plan, students alternate periods of work in school and in industry as a regular part of their degree programs.

"The principal aim of the Study," Dr. Tyler said, "is to take a careful look at the educational merits of the work-study plan for college students. We hope to learn something about the kinds of young people attracted to co-operative programs in contrast to traditional programs, something about the kinds of students for whom the co-operative experience is particularly meaningful, and about the outcome in terms of readiness for permanent employment and readiness for effective participation in civic and community affairs."

The Study also proposes, Dr. Tyler reported, to examine the economic values of co-operative education for students and for institutions operating the plan, and to examine the role of industry and business. Results of the study will be useful to officials of higher education, parents, high school guidance counsellors and industry, Dr. Tyler stated.

C. H. Kettering, inventor and longtime director of research for General Motors, serves as Honorary Chairman of the "Study of Co-operative Education." Dr. Kettering said the Study would examine the advantages and disadvantages of co-operative education. "Industrial employment during college enables colleges to train students, not for the needs of last year, nor even for this year," Dr. Kettering stated, "but for the needs of the future of which we may not even dream today."

The plan was inaugurated in 1906 at the University of Cincinnati by the late Herman Schneider, dean of engineering. It has become a well-established type of engineering education, and has been adopted in programs of business administration, education, science, and the liberal arts. Much of the growth of the plan has come since World War II.

The primary purposes of the Study of Co-operative Education are:

1. To conduct an objective, candid, and penetrating evaluation of the co-operative plan of education, as it pertains to institutions of the United States granting the baccalaureate degree.
2. To make recommendations in the area of educational policy and experimentation, and needs for further research, based upon, but not restricted to the findings of the evaluation.
3. To disseminate the findings of the evaluation and the subsequent reflections upon these findings in regard to higher education through reports, articles, and addresses.

The professional staff of the Study lists Dr. J. W. Wilson, co-ordinator of educational research at the Rochester Institute of Technology, as executive director and E. H. Lyons, industrial co-ordinator at the University of Detroit as associate director.

The Study Committee of the project includes the following, in addition to Dr. Tyler and Dr. Kettering: Dr. W. C. Fels, president of Bennington College; Dr. S. B. Gould, president of Antioch College; Dr. E. C. Harrison, president of the Georgia Institute of Technology; D. C. Hunt, director of co-ordination and placement of the University of Detroit; Dr. W. C. Langsam, president of the University of Cincinnati; K. A. Meade, director of educational relations of General Motors Corporation; Dr. D. H. Morrison, provost of Dartmouth College; K. G. Patrick, manager of educational relations and corporate support service of General Electric Company; G. E. Probst, executive director of the Thomas Alva Edison Foundation; Dr. T. G. Pullen, Jr., state superintendent of schools, Maryland; and Dr. O. M. Wilson, president of the University of Oregon.

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An Electrical Engineer in Industry

J. C. WALTER (M '42) chief engineer, communications engineering, communications products department, Radio Corporation of America (RCA).

"Aside from the obvious benefits to be derived from the excellent papers published in Transactions and *Electrical Engineering*, perhaps the most important phases of AIEE participation are the close association with engineering leaders in committee work and the development of life-long friendships which grow out of the Section and General meetings."

Beginning his professional career in 1928 after receiving his technical education at Notre Dame and George Washington Universities, Mr. Walter spent several years with the North American Company designing carrier current equipment for power line applications, joining RCA in 1936 where he designed high power broadcast transmitters in the 50- to 500-kw class. He served in the U.S. Navy during World War II as officer in charge, Shore Electronics Section, Bureau of Ships. He returned to RCA after the war to supervise the design and installation of one of the world's largest very low frequency communications transmitters, a 1,200-kw equipment commissioned at Jim Creek, Wash., in 1953. Appointed to his present position in January 1955, he is responsible for mobile and microwave land communications equipment design and for "Radiomarine" navigation and communications equipment for merchant ships, small craft, and coastal stations.

Mr. Walter has been a member of the

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AIEE Electronic Power Converters Committee (1950-54) and the Periodicals and Transactions Committee (1957-58). He has also served as chairman of the Hot Cathode Power Converters Subcommittee. He is the author of a paper which appeared in AIEE *Transactions* entitled "A Million Watt Naval Communication Transmitter."

AEC Fellowships in Nuclear Science and Engineering

Graduate students who wish to major in subjects within the field of nuclear science and engineering are eligible to apply for special Atomic Energy Commission (AEC) fellowships to support such studies.

Established to encourage more graduate students to pursue courses of study in the physical sciences and nuclear engineering, these AEC fellowships are open to first-, intermediate-, and terminal-year graduate students. Up to 150 appointments will be made for fellowships which begin in the fall of 1959. More than 40 leading universities in the United States offering the required courses in this field accept students under this program.

The basic stipend for first-year students is $1,800 for 12 months. Intermediate-year fellows receive $2,000, and terminal-year appointees are paid $2,200. An additional allowance of $500 per year is made for a wife and a maximum of two dependent children, and tuition, fees, and travel allowances are provided.

The Oak Ridge Institute of Nuclear Studies, which administers these fellowships for the AEC, has established an application deadline of January 2, 1959. Brochures and application materials are available on request from the Nuclear Science and Engineering Fellowship Office, University Relations Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

Trainer Slide Rule for Schools and Industry

A new, all plastic #120 Trainer Slide Rule for students, technicians, and general consumers is now available. It provides simple solutions to standard problems of multiplication, division, reciprocals, squares, roots, cubes, trigonometric functions, as well as logs and exponents. The ideal slide rule for the large and growing demand in today's schools and industry.

Nine basic microengraved scales (K, A, B, S, T, CI, C, D, and L) are functionally grouped for rapid learning and operation. Accurate precision scale graduations of 0.0055 inch width permanently aligned by bonding of end plates to top and bottom of the special plastic rule body. The new durable plastic in the 10-inch rule assures smooth operation under extreme high and low temperatures with easy slider action in machined grooves. Single piece, unbreakable, tinted cursor will not slide off rule.

This new quality slide rule, available in genuine vinyl case with complete instruction manual, comes individually packaged in attractive three-color box. Retail price $1.95 complete. Available now through the manufacturer, Pickett & Eckel, Inc., 542 So. Dearborn St., Chicago 5, Ill.

U-M Weather Radar Station on Wheels Studies Cloud Physics

The University of Michigan (U-M) has unveiled a new type weather radar station on wheels. It is the closest present approach to a stationary weather radar station and will be used in the study of cloud physics in efforts to learn more about precipitation.

U-M meteorologists say the station's radar scopes provide a "satellite view" of clouds going as high as 50,000 feet. Photos of the slices as they appear on the scope can be pasted together to provide an overall view of a cloud so that its configuration may be seen.

The great value of the van lies in its mobility. It can be used on lake shores, in mountains, and in other areas, beyond the most efficient range of permanently based radar. Its optimum range is between 50 and 100 miles.

Through such observations, the meteorologists hope to learn more of the actual turbulance in clouds and to determine how fast particles of rain or snow are moving. Curiously enough, the radar detects only droplets which are large enough to produce precipitation.

Prepared through facilities of the U-M Research Institute and Willow Run Laboratories, the van was completed in time for showing to some 150 engineers and meteorologists attending a 3-day conference on applied meteorology: engineering, which ended September 11.

Radioisotope Course Designed for Industry

The Atomic Energy Commission (AEC) has announced plans for a new series of radioisotope techniques courses at Oak Ridge, Tenn., especially designed for representatives of industry.

The six weeks courses will be presented by the special training division of the Oak Ridge Institute of Nuclear Studies (ORINS) as part of the AEC's development program to expand the applications of radioisotopes.

Initially, two courses have been scheduled—the first to begin February 9, and the second to start April 6.

It has been estimated that American business now is saving millions of dollars a year by using radioisotopes, and less than 1% of the manufacturing and mining concerns in the nation now are using these materials.

The AEC expects a broadening of radioisotope use will bring about substantial increases in these industrial benefits in the next few years.

The new Oak Ridge course will consist of lectures, seminars, demonstrations, and laboratory sessions. The work will emphasize practical plant applications of radioisotopes, including standard techniques of wear measurement, thickness measurements, and radiography in addition to other techniques applicable to industrial operations.

ORINS previously has given 66 courses on the basic techniques of using radioisotopes, including an occasional course dealing with specialized industrial applications. However, the series beginning next February represents a new training program aimed entirely at practicing industrial scientists and engineers.

ORINS is a nonprofit educational corporation of 36 southern universities operating under contract to the AEC.

NCE Establishes Instructor Training Program

To meet the problem of a scarcity of qualified teachers, especially in a field such as engineering where high industrial salaries lure qualified men from the classrooms, Newark College of Engineering (NCE) has instituted a program which promises real success in helping to solve the dilemma.

Realizing that too often a man suited to the teaching field is pirated away by the attractive salaries offered recent engineering graduates, NCE has inaugurated its Instructor Training Program which gives the student the opportunity of find-out out whether the teaching field is for him before he finishes his formal training.

By observing the ranks of its own students, NCE selects potential faculty members from the senior class. The students singled out are, upon graduation, given free tuition toward earning their master's degree, the title of assistant instructor with the salary of that position, and a limited teaching schedule in the day undergraduate division. A senior member of the individual department carefully instructs his new colleague in teaching methods and during the summer months the new recruit is guaranteed employment either in industry or at the college.

On the surface, the plan appears to work in favor of one party, the student. He is given the chance to obtain his master's degree, a valuable asset should he decide to go into industry and give up teaching at the end of his training period, and he is paid well while learning. In the event the student-teacher does reject teaching, industry stands to gain a more valuable employee—one who has been exposed to the creativity of teaching and who has a master's degree. The risk involved is clearly one which NCE is willing to assume. But in looking over the results of the last four years since the inception of the plan, NCE has gained an

impressive number of young men who are completely sold on the idea of teaching as a career.

The first two graduates taken into the program in September 1954, R. A. Gaal and S. B. Scrupski, have completed their training, received their master's degree in their field of specialization, and are now permanent members of the faculty of NCE with the titles instructor in mechanical engineering and electrical engineering, respectively.

Since the first 2 men were hired, a total of 13 NCE graduates have entered the program, 5 of whom have already obtained their M.S. degrees and have elected to continue their teaching careers. While it is not required by the contract, every one of the five who have completed the basic program has been advanced to the rank of instructor in recognition of his success in adapting to the art of teaching as well as having earned his master's degree. There has not been one drop-out since the program has gone into effect This last point dramatically illustrates the true test of the idea's worth and the NCE administration is well pleased with the results of the program so far. It will be a few years yet before the plan's full effectiveness can be weighed, but the college believes it has found one formula at least to strengthen its faculty recruitment program.

Minnesota Section Student Paper Contest

The AIEE Minnesota Section student paper contest was held this year at the University of North Dakota. The contest was co-sponsored by the Red River Valley Subsection and the University of North Dakota joint branch of AIEE–IRE (Institute of Radio Engineers). Participating schools were; the University of Minnesota, South Dakota State College, North Dakota Agricultural College; and the University of North Dakota.

Paul Shiebe of the University of North Dakota won first place honors for his paper "Phase Locked Oscillators Systems as Applied to Double Sideband Suppressed Carrier Communications." Second place was awarded to H. E. Fiala of North Dakota Agricultural College, and third to Jack Herrlin, of the University of Minnesota. Mr. Fiala's paper was entitled "Energy Conversion–Greatest Challenge Ever To Face Electrical Engineers," and Mr. Herrlin's "Inertial Guidance."

E. L. Lium, dean of the College of Engineering at the University of North Dakota, welcomed the group of about 75 students, faculty members, and professional engineers, who attended the banquet and contest. John Dixon, faculty advisor to the student members of AIEE, presided.

J. H. Foote, vice-president of AIEE District No. 5, spoke after the banquet, while Dean Jacobson, of the Red River Valley Subsection of AIEE, presided at the business session.

Student paper awards of $30, $20, and $15 are made available by the Minnesota Section of AIEE to first, second, and third place winners, respectively.

N.C. Engineering Foundation Plans To Finance Professorships

The North Carolina Engineering Foundation has announced plans to finance the establishment of seven distinguised professorships in the School of Engineering at North Carolina State College, Raleigh, N.C.

In a statement, Governor Hodges commended the Engineering Foundation for "constructive leadership" in creating the professorships and said the action will advance the State's industrial development.

E. A. Clement of Raleigh, president of the Engineering Foundation, said the professorships—designed to retain and attract top-ranking teachers and scientists for service in the State College School of Engineering—have been authorized by the Executive Committee of the Board of Trustees of the Consolidated University of North Carolina.

Establishment of the professorships will enable the college to provide substantial supplements to the State salary scale for the employment of a core of outstanding engineering educators.

Since it was organized in 1944, the Engineering Foundation has provided financial support to the College's School of Engineering. The professorships are a further extension of this support.

College officials explained that the professorships will lift the prestige of the School of Engineering as a regional and national leader in science and engineering education.

Dr. J. H. Lampe, dean of engineering at the College, declared, "This is another outstanding contribution of the Engineering Foundation in its continuing effort to stimulate and encourage our faculty."

He predicted the professorships will place the academic work of North Carolina State in the national spotlight and will add to the college's reputation as a leading American center of education and research.

President Clement said the Engineering Foundation's Board of Directors has approved a 1958-59 annual budget of nearly $90,000 for all of its supplements to the State College School of Engineering.

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"This Atomic World" To Visit Schools in 15 States

With the opening of the 1958-59 school year, seven panel trucks left the American Museum of Atomic Energy to begin the fourth year of the Atomic Energy Commission (AEC) high school demonstration program "This Atomic World." This year's schedule will bring the program to 1,069 schools in 15 states before the end of the school year.

Since its beginning in 1955, "This Atomic World" has traveled to high schools in every state in the union and the District of Columbia with its program designed to stimulate the interest of young people in science and science-teaching careers. As with all AEC traveling exhibits operated by the Oak Ridge Institute of Nuclear Studies (ORINS) Museum Division, the program is made available without charge.

In addition to "This Atomic World," ORINS administers 24 other traveling exhibit units of three major types, and operates the American Museum of Atomic Energy in Oak Ridge for the AEC.

AT THE Minnesota Section Student Paper Contest were: (*left to right*) Paul Scheibe, paper contest winner of University of North Dakota; Wray Wentworth, chairman of AIEE–IRE joint Student Branch at University of North Dakota; Jack Herrlin, third place winner of Minnesota University; Larry LaCoursiere, Branch vice-chairman for AIEE; Harvey Fiala, second place winner from North Dakota Agricultural College; J. H. Foote, vice-president of AIEE District No. 5; John Metzger, Branch secretary for IRE; Lyle LaRiviere, Branch secretary-treasurer for AIEE.

INSTITUTE ACTIVITIES

1959 Winter General Meeting Scheduled for February 1-6 in New York

THE AIEE Winter General Meeting will be held February 1—6, 1959. Because of the large number of technical sessions covering all six Technical Divisions of the Institute, meetings will take place in both the Statler and the Sheraton-McAlpin Hotels, New York, N.Y. As usual, the Statler will be headquarters for the meeting.

As this is being written long before the closing date of the papers, it is impossible to give even an approximation of the number of papers which will be presented; however, indications are that the number of Transactions and Conference papers will exceed those of last year.

Informal Tea

This social gathering before the formal program begins has been enjoyed by more and more people each year. Make it a point to attend this year—Sunday afternoon, February 1, from 4 to 6 p.m., in the Penn Top of the Statler. There will be no charge.

During this period, the registration facilities will be open for those who wish to avoid the Monday morning rush.

Hotel Reservations

Blocks of rooms have been set aside at the Statler and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent to the hotel of your choice, specifically referring to the AIEE meeting in your letter. Please do not write to more than one hotel. If your request cannot be filled, the hotel will automatically refer your request to the Hotel Accommodations Committee whose duty it is to obtain a similar reservation at another of the convention hotels. The hotel will confirm directly to you. No guarantee that you will be housed satisfactorily can be made if your request is received after January 12, 1959.

Because of the crowded conditions in New York hotels, it is suggested that reservations be made for arrival on Sunday, February 1, 1959, thereby avoiding delays in registration or unavailabilty of rooms in the early morning of subsequent days. It is also suggested that a request for reservation prior to Christmas is more likely to be filled at the hotel of your choice.

Rooms have been allotted for our use by the following hotels at the daily rates indicated below:

Hotel Statler (meeting headquarters), 7th Ave. 32nd St. to 33rd St.	
Single Room	$ 8.00 to $14.00
Double Room	11.00 to 18.00
Twin Bedroom	15.00 to 22.00
Hotel Sheraton-McAlpin (also used for meetings), Broadway and 34th St.	
Single Room	$ 8.00 to $12.50
Double Room	11.00 to 15.50
Twin Bedroom	12.00 to 15.50
Hotel New Yorker, 8th Ave. at 34th St.	
Single Room	$ 8.00 to $14.50
Double Room	11.50 to 18.00
Twin Bedroom	15.00 to 20.00
Hotel Martinique, Broadway and 32nd St.	
Single Room	$ 6.50 to $11.00
Double Room	9.50 to 14.50
Twin Bedroom	9.50 to 14.50
Hotel Governor Clinton, Seventh Ave. at 31st St.	
Single Room	$ 7.50 to $12.00
Double Room	11.00 to 14.00
Twin Bedroom	12.00 to 17.00
Hotel Commodore, Lexington Ave. and 42nd St.	
Single Room	$ 7.00 to $17.00
Double Room	13.00 to 19.00
Twin Bedroom	13.00 to 20.50
Hotel Roosevelt, Madison Ave., and 45th St.	
Single Room	$ 8.50 to $19.50
Double Room	13.50 to 23.50
Twin Bedroom	17.50 to 24.50

All rooms have private bath and the rates quoted are subject to a 5% New York City hotel room tax.

Courtesy Ross Photos

DISCUSSING PLANS FOR THE 1959 AIEE Winter General Meeting are: (*standing, left to right*) D. M. Quick, past chairman, Winter General Meeting Committee; E. J. Doyle, chairman, Dinner-Dance Committe; M. Lennig, Hotel Accommodations Committee; C. E. Dean, Registration Committee; A. Grabel, chairman, Monitors Committee; W. T. Rea, chairman, New York Section; H. G. Koch, chairman, Inspection Trips Committee; D. E. Winslow, chairman, Hotel Accommedations Committee; J. R. Kerner, vice-president AIEE District No. 3; N. S. Hibshman, National secretary; E. C. Day, assistant secretary, Technical Operations Department; (*seated, left to right*) C. T. Hatcher, chairman, Technical Operations Department; Mrs. D. M. Quick, chairman, Ladies Committee; R. T. Weil, Jr., chairman, Winter General Meeting Committee; R. W. Gillette, vice-chairman, Winter General Meeting Committee; J. J. Anderson, secretary, Winter General Meeting Committee; T. C. Oliver, chairman, Registration Committee.

Smoker

A highlight of the Winter General Meeting will be the Smoker to be held Tuesday evening, February 3, 1959. Good food, good fellowship, and top quality entertainment will be the feature of this event which will take place in the Hotel Statler.

Attendance will be limited for the comfort of the guests. Ticket requests should be mailed at an early date. The price will be $11 per ticket and requests should be addressed to "AIEE Smoker Committee," 33 W. 39th St., New York 18, N.Y., accompanied by checks made payable to "Special Account, Secretary, AIEE."

Dinner-Dance

Dinner-Dance will be held Thursday evening, February 5, in the Hotel Statler. Dress will be formal. Write soon for reservations for tables for 10. The price this year is $12.50 per ticket and requests should be sent to "AIEE Dinner-Dance Committee" at 33 W. 39th St., New York 18, N.Y., accompanied by checks made payable to "Special Account Secretary, AIEE."

Inspection Trips

A program of inspection trips is presently being prepared which will include

many of the more popular trips scheduled in prior years as well as others that have not been available previously. Included in the schedule are trips to: Abilities Inc., Bell Telephone Laboratories, Brookhaven National Laboratories, Consolidated Edison Company's Astoria Generating Station, Holophane Light and Vision Institute, International Business Machines Corporation, Leeds and Northrup, Leviton Manufacturing Company Inc., New York Times, Radio City Music Hall, Rambusch Decoration Company, Steinway Piano Company, Underwriters' Laboratories, United Nations Building, Western Electric Company.

As in the past, advanced registration will be accepted for selected tours.

Ladies Entertainment

The Ladies Entertainment Committee hopes it may greet many ladies at the Winter General Meeting and has arranged an interesting program for the week.

Registration: Ladies register with their husbands and obtain their name badges before registering for the events of the Ladies Program. Ladies registration starts Sunday afternoon in Ladies Headquarters from 2 to 4 p.m.

Ladies Headquarters in the Washington Room of Hotel Statler will be open throughout the week.

Coffee Hour will be held each morning in the Ladies Headquarters, Monday through Friday.

Program: *Monday*—Get-Acquainted Tea. *Tuesday*—Sightseeing Tour of lower Manhattan with a visit to the new Stock Exchange and lunch in Chinatown; in the evening a dinner with cocktails and entertainment. *Wednesday*—United Nations Tour with lunch in the Delegates Dining Room. *Thursday*—Breakfast at Altman's followed by a millinery show; at noon a luncheon and Fashion Show. *Friday*—A visit to Gompertz Fur Shop in the center of New York's fur market or a trip to the Interior Design Center.

Winter General Meeting Committee

Members of the 1959 Winter General Meeting Committee are: R. T. Weil, Jr., chairman; R. W. Gillette, vice-chairman; J. J. Anderson, secretary; J. R. Kerner, budget co-ordinator and AIEE vice-president for District No. 3; C. T. Hatcher, chairman, Technical Operations Department; J. A. Parrott, public relations; W. T. Rea, general session; D. E. Winslow, hotel accommodations; T. C. Oliver, registration; H. G. Koch, inspection trips; Arvin Grabel, monitors; D. Halloran, smoker; E. J. Doyle, dinner-dance; Mrs. D. M. Quick, ladies entertainment; D. M. Quick, ex-offico member (past-chairman).

Cancellation of the AIEE Fall General Meeting

AS THIS ISSUS goes to press, AIEE has just had the distressing experience of having to cancel a General Meeting. Plans and announcements for the 1958 Fall General Meeting in Pittsburgh, Pa., had all been made. Some 255 papers, the largest number of papers ever presented at a Fall meeting, had been scheduled. Two major medals were to be presented. Panel discussions on timely subjects had been arranged. Several programs were built around the theme of the Bicentennial of the host city, and its civic and research achievements. A record registration was anticipated. Then, on October 1, the employees of the five major hotels in Pittsburgh went out on strike; practically paralyzing the convention facilities of the city.

No suitable place could be found to which the meeting could be moved for the dates announced. Chicago and Atlantic City hotels offered later dates. The Chicago and Philadelphia Sections stood ready to jump into the breach. However, after considering all the possibilities in an hour-long telephone conference meeting, the Executive Committee of the Board of Directors decided that to change both the location and the date of the meeting on such short notice, would not be feasible. It was on the afternoon of Wednesday, October 15, that the decision was reached to cancel the meeting, if the strike was not settled by Friday night, October 17. It wasn't; and on Saturday morning, the now familiar postal cards went into the mail, carrying their sad story to members all over the world.

The decision to cancel was a hard one to make. It meant that all of the months of hard work and preparations by the Pittsburgh General Meeting Committee, the Technical Committees that had arranged the sessions, and by the authors who had prepared the papers, would be lost or at least suffer in some degree from postponement. The timely opportunity to get Committees, Divisions, and Departments together early in the year would be lost. However, it was the majority opinion of the Executive Committee that cancellation would, in the long run, be the best solution. The rescheduling of 250 authors, to say nothing of making hotel reservations and assembling physical facilities, held a strong promise of adding confusion and frustration to disappointment.

When the Technical Committees, the Divisions, and the Technical Operations Department met during the last week in October plans for salvaging as much as possible of the technical program were made. As already announced, Transactions Papers will be published on schedule in the Bimonthlies and the annual volumes. Discussions received by mail before December 1 will be in time for publication with the papers. Numbered Conference Papers are also available for mail order.

The Board of Directors decided by mail ballot to cancel its meeting which was set for October 31. Routine business of the Board will be conducted by the Executive Committee at its meeting of December 11, 1958. Departments and Committees are in the process of rescheduling their meetings as this is written. All are determined to "pick up the pieces" and make the best of it. Indications are that at least some of the Fall General Meeting program will be included in the Winter General Meeting in New York, N.Y., February 1-6, 1959. This will certainly be true of the presentations of the AIEE Medal in Electrical Engineering Education and the John Fritz Medal, both of which were scheduled to be given in Pittsburgh. The January issue of *Electrical Engineering* will have the full story of the 1959 Winter General Meeting.

Bimonthly Publications

The bimonthly publications, *Communication and Electronic Applications and Industry* and *Power Apparatus and Systems* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. Members may receive one subscription to any *one* of the bimonthlies for $2.50. The balance of the annual $5.00 subscription price will be paid by application of his annual dues for the year of the subscription. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional member subscriptions wil lbe at the rate of $5.00. Nonmembers may subscribe on an advance annual subscription basis of $8.00 each (plus 50¢ extra for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.50 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Many Attend Sectional Meeting of the World Power Conference

The World Power Conference Canadian Sectional Meeting, held in Montreal Que., September 7-11, 1958, and attended by over 1,300 participants from 50 countries, discussed the theme "Economic Trends in the Production, Transportation, and Utilization of Fuel and Energy." Some 14 papers by United States authors were presented and about 100 United States engineers, headed by K. M. Irwin as chairman, attended.

The delegates from the United States took an active part in the discussion of the 147 technical papers covering the three main divisions—production, transportation, and utilization—of the Conference theme. During the meeting, delegates were afforded an opportunity to visit industrial enterprises and construction projects in the Montreal area. Following the Conference, many participants took study tours. Of

greatest interest as indicated by attendance was the tour to the St. Lawrence River power and navigation projects, to Niagara Falls power projects, to the Nuclear Power Station at Shippingport, Pa., and ending in New York City in time for the 6th International Congress on Large Dams.

The next Sectional Meeting will be held in Madrid, Spain, June 5-9, 1960, on the theme "Methods for Solving Power Shortage Problems." It will be preceded by a meeting of CIGRE (International Conference on Large Electric Systems) and followed by a meeting of the International Commission on Irrigation and Drainage.

AIEE, American Society of Civil Engineers, American Society of Mechanical Engineers, and American Institute of Chemical Engineers support the World Power Conference by financial contribution to, and representation on, the U. S. National Committee.

Tentative Program Announced for 1958 Eastern Joint Computer Conference

THE 1958 Eastern Joint Computer Conference and Exhibit will be held December 3-5, at the Bellevue-Stratford Hotel, Philadelphia, Pa.

The tentative technical program for the 3-day Conference, sponsored by AIEE, Institute of Radio Engineers, and Association for Computing Machinery, follows.

Tuesday, December 2

7:00 p.m. Registration

Wednesday, December 3

8:00 a.m. Registration

10:00 a.m. Opening Session

Chairman: F. M. Verzuh, Massachusetts Institute of Technology

2:00 p.m. Session II—Reliability and Components

Chairman N. P. Edwards, International Business Machines Corporation

Part A. "Reliability of Data-Processing Equipment"

Athena Computer: A Reliability Report. *G. A. Raymond, L. W. Reid,* Remington Rand

Philosophy of Automatic Error Correction. *R. M. Block,* Datamatic Division of Minneapolis-Honeywell

The Systems Approach to Reliability. *H. D. Ross,* International Business Machines Corporation

Part B. "Modern Computer Components"

Impulse Switching of Ferrites. *R. E. McMahon,* Massachusetts Institute of Technology, Lincoln Laboratory

A High-Speed High-Capacity Photo Memory. *C. A. Lovell,* Bell Telephone Laboratories

Design Criteria for Long-Wearing Computer Tape. *J. W. Wenner,* International Business Machines Corporation

Thursday, December 4

9:00 a.m. Session III—The Impending Revolution in Computer Technology

Chairman: Rex Rice, IBM Research Center

Part I. "Status of Present Research"

Introduction: R. Rice, IBM Research Center

Computer Design from the Programmer's Viewpoint. *W. F. Bauer,* Space Technology Laboratory, Ramo-Wooldridge Corp.

Device, Circuit, and Logical Element Trends. *Dudley Buck,* Massachusetts Institute of Technology

New System Design Techniques. *R. K. Richards,* Consultant

Part II. "Speculation on Future"

Should we abandon the general-purpose coding and machine concepts?

Programming Perspectives. *W. F. Bauer*

System Design. *R. K. Richards*

Devices Leading to Self-Organizing Systems. *Dudley Buck*

2:00 p.m. Session IV—Organization and Processing of Information

Chairman: W. Orchard-Hays, Corporation for Economic and Industrial Research

Part A. "Organizational and Programming Methods"

An Information Filing and Retrieval System for the Engineering and Management Records of a Large-Scale Computer Development Project. *G. A. Bernard III, Louis Fein,* Ampex Corporation

File Problems Connected with a National Menu Study. *P. M. Thompson, Market Research* Corporation of America

Data Processing and Information Production. *R. H. Gregory, Martin Trust,* Massachusetts Institute of Technology

Part B. "Hardware and Systems Methods"

NBS Multicomputer System. *A. L. Leiner, W. A. Notz, J. L. Smith, A. Weinberger,* National Bureau of Standards

Data Handling by Control Words. *G. A. Blaauw,* International Business Machines Corporation

2:00 p.m. Session V—Design Techniques

Chairman: F. H. Tendick, Bell Telephone Laboratories

Special-Purpose Computer Design by Simulation. *P. L. Phipps,* Remington Rand Univac

Logical Design Techniques for *CG-24*, A General-Purpose Real-Time Computer. *G. P. Dineen, I. L. Lebow, I. S. Reed,* Massachusetts Institute of Technology, Lincoln Laboratory

Design Criteria for Autosynchronous Circuits. *J. C. Sims, Jr.,* Sylvania Electric Products, Inc.; *H. J. Gray,* University of Pennsylvania

Analysis of *TRL* Circuit Propagation Delay. *W. J. Dunnet, E. P. Auger, A. C. Scott,* Sylvania Electric Products, Inc.

The Recording, Checking, and Automatic Printing of Transistor Logical Diagrams. *P. W. Case, M. Kloomok,* International Business Machines Corporation

Friday, December 5

9:00 a.m. Session VI—Special Applications

Chairman: E. L. Harder, Westinghouse Electric Corporation

System Evaluation and Instrumentation Using Simulation Equipment. *A. J. Strassman, L. H. Kurkjian,* Hughes Aircraft Co.

Automatic Programming System for Translation of Russian to English. *V. E. Giuliano* Harvard Computation Laboratory

APAR—Automatic Programming and Recording. *G. R. Bachand, J. L. Rogers, T. F. Marker,* Sandia Corp.

DYANA—Dynamics Analyzer-Programmer. *T. J. Theodoroff,* General Motors Corp.

Univac Air Lines Reservations Systems. *C. W. Fritze, V. E. Herzfeld, D. K. Sampson,* Remington Rand Univac

2:00 p.m. Session VII—New Computers

Chairman: T. H. Bonn, Remington Rand Univac

The Siemens Digital Computer-*2002*. *Dr. Heinz Guzin,* Siemens & Halske, A. G., Munich, Germany

Design of the RCA *501* System. *T. M. Hurewitz, J. G. Smith,* Radio Corporation of America

The IBM *7070* Data-Processing System. *R. W. Avery, S. H. Blackford, J. McDonnell,* International Business Machines Corporation

Performances Advances in a Transistorized Computer System, the TRANSAC *S-2000*. *R. J. Segal, J. L. Maddox, P. Plano,* Philco Corporation

Programming Design Features of Gamma *60* Computer. Speaker: Philippe Dreyfus, Cie Des Machines Bull, Paris, France

Over 900 Attend AIEE-ASME National Power Conference

BOSTON, MASS., was the scene of the second annual National Power Conference, held September 29—October 1, 1958, under the joint sponsorship of the Power Divisions of AIEE and The American Society of Mechanical Engineers (ASME). Registration for the 3-day meeting exceeded 900.

Technical sessions, held during the three days and the evening of September 29 at the Statler Hilton Hotel, were supplemented by inspection trips to nearby companies concerned with power generation or the manufacture of power generating equipment. Trips scheduled included the Allis-Chalmers Manufacturing Company at Hyde Park, Mass., General Electric Company at Lynn, Mass., the Salem Harbor plant of the New England Electric System, and the Mystic Station of the Boston Edison Company, as well as a tour of an aircraft carrier, missile cruiser, and atomic submarine.

At the banquet held Tuesday night, Capt. J. M. Dunford, USN, deputy to Adm. H. G. Rickover, was the principal speaker. He predicted a more and more important role for nuclear power in the U. S. Navy. He stated that the cruises of the nuclear-powered submarines *USS*

AIEE Future Meetings

AIEE-IRE-ACM Eastern Joint Computer Conference (Exhibit)*
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958

AIEE-IRE Second National Symposium on Communication Systems (Exhibit)*
Colonial Inn-Desert Ranch
St. Petersburg Beach, Fla.
December 3-5, 1958

AIEE-IRE-ASQC-EIA National Symposium on Reliability and Quality Control*
Bellevue-Stratford Hotel
Philadelphia, Pa.
January 12-14, 1959

Winter General Meeting*
Statler Hotel
New York, N. Y.
February 1-6, 1959

AIEE-IRE-U of P Transistor and Solid-State Circuits Conference
University of Pennsylvania
Philadelphia, Pa.
February 12-13, 1959
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Dec. 9)

AIEE-IRE-ACM Western Joint Computer Conference
Fairmont Hotel
San Francisco, Calif.
March 3-5, 1959
(Final date for †TP—Dec. 3, ‡CP Syn.—Dec. 19, CPMs—Dec. 29)

AIEE-ASME-IIT American Power Conference
Sherman Hotel
Chicago, Ill.
March 31-April 2, 1959
(Final date for †TP—Dec. 31, ‡CP Syn.—Jan. 16, CPMs—Jan. 26)

EJC Nuclear Congress
Municipal Auditorium
Cleveland, Ohio
April 5-10, 1959

Electric Welding Conference
Chicago, Ill.
April 6-10, 1959
(Final date for †TP—Jan. 6, ‡CP Syn.—Jan. 20, CPMs—Jan. 30)

AIEE-ASME Railroad Conference
Chicago, Ill.
April 7-9, 1959
(Final date for †TP—Jan. 7, ‡CP Syn.—Jan. 23, CPMs—Feb. 2)

Southern District Meeting
Dinkler Plaza Hotel
Atlanta, Ga.
April 8-10, 1959
(Final date for †TP—Jan 8, DPMs—Feb. 2)

Electric Heating Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
April 14-15, 1959
(Final date for †TP—Jan 14, ‡CP Syn.—Jan. 30, CPMs—Feb. 9)

Electrical Problems in the Cement Industry Conference
Allentown, Pa.
April 16-17, 1959
(Final date for †TP—Jan. 16, ‡CP Syn.—Jan. 30, CPMs—Feb. 10)

Recording and Controlling Instruments Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
April 20-21, 1959
(Final date for †TP—Jan. 20, ‡CP Syn.—Feb. 3, CPMs—Feb. 13)

East Central District Meeting
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, DPMs—Feb. 16)

Rubber and Plastics Conference
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, ‡CP Syn.—Feb. 6, CPMs—Feb. 16)

Empire District Meeting
Hotel Syracuse
Syracuse, N. Y.
April 29-May 1, 1959
(Final date for †TP—Jan. 29, DPMs—Feb. 23)

AIEE-IRE-EIA-WCEMA Joint Electronic Components Conference
Benjamin Franklin Hotel
Philadelphia, Pa.
May 6-8, 1959
(Final date for †TP—Feb. 5, ‡CP Syn.—Feb. 20, CPMs—March 2)

AIEE-ASME-IRE Automatic Techniques Conference
Pick-Congress Hotel
Chicago, Ill.
May 11-13, 1959
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 24, CPMs—March 6)

Domestic Appliances Conference
Pick-Carter Hotel
Cleveland, Ohio
May 18-19, 1959
(Final date for †TP—Feb. 17, ‡CP Syn.—March 3, CPMs—March 13)

Middle Eastern District Meeting
Lord Baltimore Hotel
Baltimore, Md.
May 19-21, 1959
(Final date for †TP—Feb. 18, DPMs—March 13)

AIEE-ISA-ARS-IAS National Telemetering Conference
Brown Palace and Cosmopolitan Hotel
Denver, Colo.
May 24-27, 1959
(Final date for †TP—Feb. 23, ‡CP Syn.—March 10, CPMs—March 20)

Summer and Pacific General Meeting
Olympic Hotel
Seattle, Wash.
June 21-26, 1959
(Final date for †TP—March 23, ‡CP Syn.—April 7, CPMs—April 17)

Petroleum Industry Conference
Wilton Hotel
Long Beach, Calif.
August 25-27, 1959
(Final date for †TP—May 27, ‡CP Syn.—June 12, CPMs—June 23)

AIEE-ASME Engineering Management Conference
Los Angeles, Calif.
September 16-18, 1959
(Final date for †TP—June 18, ‡CP Syn.—July 3, CPMs—July 13)

Magnetic Amplifiers Conference
Shoreham Hotel
Washington, D. C.
September 23-25, 1959
(Final date for †TP—June 25, ‡CP Syn.—July 10, CPMs—July 20)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 11-16, 1959
(Final date for †TP—June 12, ‡CP Syn.—July 30 CPMs—Aug. 7)

Machine Tools Conference
Hotel Cleveland
Cleveland, Ohio
October 19-21, 1959
(Final date for †TP—July 21, ‡CP Syn.—Aug. 4, CPMs—Aug. 14)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Authors Guide*.
For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N.Y.

Skate and *Nautilus* under the North Pole have served to demonstrate that the Navy and the Atomic Energy Commission have gained for this country a clear-cut advantage in a vital military field. "The nuclear submarines have developed tactics and ways of operation which were undreamed of a few years ago," he added.

Of particular interest to AIEE members was an address at the Wednesday luncheon by T. M. Linville, research operations manager, General Electric Company, and former AIEE director, who discussed the new United Engineering Center, to be constructed at United Nations Plaza in New York City. He briefly touched on the events leading up to the acquistion of the site, and explained how the funds for the Center are being raised. In describing the member-giving campaigns now under way in the various engineering societies, he related his experiences with the successful fund-raising in the Schenectady Section of the AIEE.

Technical Sessions

Steam Power Plant Design. The first session, held Monday morning, was devoted to three papers on steam power plant design. E. H. Krieg of Stone & Webster Engineering Corporation made predictions for the future in the field of power stations. It is estimated that the 1957 facilities of 135 million kw may expand to 365 million kw by 1977 and 735 million kw by 1997. Atomic power will probably become more economical than power generated from coal, because coal costs are subject to increased mining and transportation costs, whereas uranium costs tend to decrease. Progress is now being made in research in thermonuclear fusion, solar energy furnaces, and other sources of electric energy.

A paper by H. C. Barnes of American Electric Power Service Corporation, C. S. Murray of Consolidated Edison Company of New York, and V. E. Verrall of Central Illinois Public Service Company outlined relay protection practices in steam power stations. Emphasized was the problem of dependability, with the resultant need for co-ordination of all protective devices, both mechanical and electrical, in a station.

Two 325,000-kw turbine–generator units operating at supercritical steam pressures are being installed in the Philadelphia Electric Company's new Eddystone Station, as reported in a paper by J. A. Adams. His discussion covered the auxiliary power supply, which consists of a separate system for each main unit and a station auxiliary power system to supply common plant equipment, station services, and starting requirements. A high degree of reliability has been achieved through simplicity of design, omission of complicated throwover schemes, and the use of modern equipment of adequate capacity.

Steam Turbine Generator Design. At the Monday afternoon session, J. D. Waddell of Maine Public Service Company presided. The "rapporteur" technique was used for the first time at this session. In place of the customary procedure in which the individual papers are presented by the authors, a reporter summarizes all of the papers and then questions and comments are encouraged from the audience. At this session, J. J. Kearney, assistant managing technical editor, *Electrical World*, served as reporter, and reviewed the following papers on large steam turbine-generator design:

"Modern Large Steam Turbines and Generators," by C. C. Franck, Sr., and J. W. Batchelor, Westinghouse Electric Corporation.

"Design Features and Characteristics of Large Steam Turbine–Generators," by S. C. Barton, J. A. Massingill, and H. D. Taylor, all of General Electric Company.

"Current Large Steam Turbine–Generator Design Practice" by J. J. Fleischmann and G. W. Staats, Allis-Chalmers Manufacturing Company.

Career Possibilities. Career opportunities for young engineers in the power field were discussed in four papers presented at a Monday evening session.

A suggested undergraduate curriculum in mechanical engineering which will be sufficiently broad to equip students to handle the many prospective sources of power was outlined in a paper by J. H. Keenan, J. A. Fay, and G. N. Hatsopoulos, all of the department of mechanical engineering, Massachusetts Institute of Technology (MIT). A parallel, alternative program for the less analytically inclined students was also suggested.

In "Education for Expanding Horizons in Electric Power," G. S. Brown, head of the department of electrical engineering at MIT, recommended that engineering school curricula be more solidly based on science and applied science at the expense of specialized knowledge. He also stated that the key to the much-needed communication between electric power industry leaders and engineering college professors is the initiation of bigger and more open-ended programs of on-campus research under direct industry sponsorship.

Some of the new roles and responsibilities which will be assumed in the lifetime of today's young engineer were brought out by F. A. Kramer of the Public Service Electric & Gas Company, Newark, N.J.

The session closed with "An Engineer in the Power Field" by V. F. Estcourt, Pacific Gas & Electric Company. He stated that recent technological advances have had an effect upon the quality and organization of engineering manpower in the utilities and in types of skills required for a successful career in this industry. These developments have required a readjustment of utility management practices in the training, utilization, and salary standards of engineers. All of these factors have impressively affected the outlook for an engineering career in the power field.

Nuclear and Marine Power. J. P. Den Hartog, professor of mechanical engineering at MIT, served as chairman at a Tuesday morning session devoted to nuclear and marine power. Andrew Kramer, editor, *Plant Engineering*, was the reporter. He presented, in summary form, the following papers:

"The Yankee Atomic Electric Plant," by R. J. Coe, Yankee Atomic Electric Company, and W. E. Shoupp, Westinghouse Electric Corporation.

"A High-Temperature Pebble Bed Reactor–Steam Power Plant of 125 Mw," by R. F. Benenati of Sanderson and Porter Engineers.

"The Dresden Nuclear Power Station," by V. A. Elliott and V. D. Nixon, both of the General Electric Company, R. D. Maxson of the Commonwealth Edison Company, and J. W. Merryman of the Bechtel Corporation.

"Enrico Fermi Atomic Power Plant," by R. W. Hartwell, A. P. Donnell, and H. A. Wagner, Power Reactor Development Company.

"Performance Tests of a Vertical Steam

Los Alamos Subsection Installs Officers

AT A RECENT DINNER MEETING held at the Los Alamos Golf Club, the Los Alamos Subsection of the AIEE held installation ceremonies for the 1958 officers who are: (*left to right*) Earl Swickard, vice-chairman; Lloyd Lanham, chairman; and Rudolph Velasco, secretary-treasurer. Committee chairmen appointed were: Edward Tagliaferri, publicity; Dan Pfaff and John Buchen, program; Don Elliot, arrangements; and William Aiello, membership.

Generator for Nuclear Power Plants," by R. L. Coite and C. C. Peake, Westinghouse Electric Corporation.

"Application of Boiling Water Reactor for Merchant Ship Propulsion," by R. L. Schmidt, General Electric Company.

Power Transmission and Industrial Power. Four papers on power transmission and industrial power were featured at a Wednesday morning session. The first of these, "D-C Transmission—An American Viewpoint," was written by G. D. Breuer, M. M. Morock, L. W. Morton, and C. A. Woodrow, all of the General Electric Company. Recent activity in Sweden, England, France, the Soviet Union, and other countries has reawakened American interest in possibilities of d-c transmission in certain applications. Examples of applications in which d-c transmission could be economically feasible are (1) where considerable amounts of underground cable are required and (2) where overhead transmission distances of 500 miles or greater are justified.

A paper by E. A. Shultz and T. W. Schroeder of the Illinois Power Company described operating experience of a power pool set up in 1952 by their company, the Central Illinois Public Service Company, and the Union Electric Company of Missouri. Substantial economies have been effected through its operation. The authors claim that in a pool of this nature each participant can retain full autonomy and yet achieve the benefits of pool operation by approaching each problem with an absolute sense of fairness and adherence to the "one system" concept.

In "Industrial Power Is Different," R. K. Patterson of Charles T. Main, Inc., Boston, Mass., pointed out some of the differences in approach between industrial power and electric utility power. If a manufacturing plant furnishes most of its own energy requirements, more attention should be paid to capital costs than to operating efficiency.

T. J. Judge of the International Paper Company, Southern Kraft Division, discussed trends in power plant design for modern paper mills. During the past decade, the electrical requirements at the larger paper manufacturing facilities has grown from 28,000 to as high as 80,000 kw. Some highlights of the design features of present and future equipment were outlined.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until December 26. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before December 26.

57-786 **A Review of Telephone Development in Western Europe and in Underdeveloped Areas.** *G. D. Wallenstein*

57-809 **Subdivision of Telephone Traffic.** *Imre Molnar*

57-1097 **A Miniaturized Negative Impedance Voice Repeater Employing Transistors.** *A. S. Howell*

58-118 **Terminal Spacings for High-Altitude and Ultrahigh-Temperature Electronic Transformer Applications.** *G. I. Duncan, W. A. Rectanus*

58-173 **Volt-Second Transfer Efficiency in Fast-Response Magnetic Amplifiers. Part II: N^2/R as a Design Parameter.** *T. J. Pula, G. E. Lynn, J. F. Ringelman*

58-224 **Anode Breaker Testing with a High-Capacity Rectifier System.** *L. J. Harris, T. J. Scully, V. N. Stewart*

58-326 **Properties of Octafluorocyclobutane—A Dielectric Gas.** *F. W. Blodgett*

58-401 **The Evaluation of Enameled Magnet Wire.** *H. L. Saums, W. W. Pendleton*

58-814 **Pagemaster Receiver and Modulation Equipment.** *J. W. Young*

58-903 **An Automatic Gage Controller for a 56-Inch Reversing Steel Mill.** *R. L. Duke, L. R. Hulls*

58-920 **The Electric Analog for Determining Temperature Distribution in Electrical Components.** *E. R. G. Eckert, J. P. Hartnett, T. F. Irvine, Richard Birkebak.*

58-1025 **Matrix Synthesis of High-Speed Logic.** *E. J. Schubert*

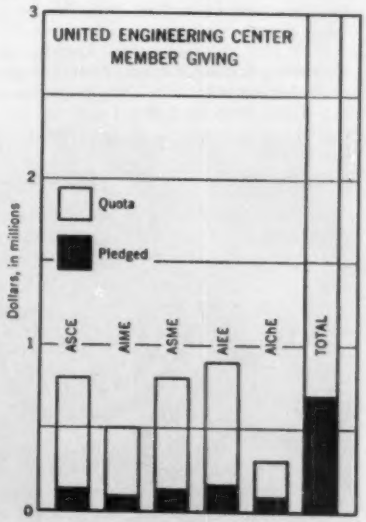
Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N.Y.

A Current Study of the United Engineering Center

A current study of the new United Engineering Center shows that the present planning provides for a 22-story tower occupying 25% of the plot area. This is the maximum allowed under New York City ordinances.

The basement and the first two stories which will occupy the full plot area will be devoted to those purposes which require large movements in and out, such as meeting conference rooms, engineering and scientific exhibits, cafeteria, library, storage, and centralized services. The general planning calls for the use of the tower for the offices of the individual societies.

The estimated gross area will be about 280,000 square feet and the net usable area about 190,000 square feet, the difference being required for mechanical equipment, elevators and elevator lobbies, corridors, and shafts.



THIS is the status of member giving as of October 16, 1958. All contributions to the United Engineering Trustees, Inc., Building Fund are tax deductible.

ECPD Holds 26th Annual Meeting

M. D. Hooven

W. L. Everitt

W. S. Hill

THE ANNUAL MEETING of the Engineers' Council for Professional Development (ECPD) was held this year on October 9 and 10 at the Jefferson Hotel in St. Louis, Mo. The program followed the usual pattern. The Council, consisting of three representatives of each of the eight participating bodies, met successively in "administrative," "executive," and "open" sessions to transact business, accredit engineering curricula, and hear reports from the eight major operating committees. Committee meetings likewise were held both for the conduct of business and, as open sessions, to review and demonstrate the work of the committees for all interested.

Business transacted by the Council of ECPD included the election of officers and appointment of committees; the approval of a definition of Engineering: the opening of the meetings of the Education and Accreditation Committee to a qualified observer selected by each of the Participating Societies from their Boards or Committees on Education; a request to the American Society for Engineering Education (ASEE) to conduct a study of criteria for accrediting technical institutes; action to encourage broader participation in the nomination of ECPD committee men; and the authorization of a committee to study co-operative activities with Engineers Joint Council (EJC).

M. D. Hooven, past-president of AIEE, completed at this Annual Meeting a 2-year term as President of ECPD. W. L. Everitt, past-director of AIEE, was elected President of ECPD for the year 1958-59. The new President is dean of engineering at the University of Illinois. He received the AIEE Medal in Electrical Engineering Education for 1957. A number of AIEE members were elected to or continued in other prominent posts:

W. S. Hill (F '50), manager, Engineering Recruiting Section, General Electric Company, Schenectady, N. Y., was reappointed to a 3-year term on Council and was continued as a member of the Executive Committee.

F. C. Lindvall (F '43), chairman, Engineering Division, California Institute of Technology, will head the Education and Accreditation Committee, a position previously held by the new President.

G. H. O'Sullivan (F '48), vice-president, new business, J. G. White Engineering Corporation, New York, N. Y., will continue as chairman of the Recognition Committee.

P. L. Alger (F '30), consulting engineer, General Electric Company, Schenectady, N. Y., was elected chairman of the Ethics Committee.

S. L. Marras (AM '52), as Secretary of UET, will serve ECPD as treasurer.

The office of secretary which customarily rotates among the secretaries of the Five Founder Societies, will also be filled by AIEE in 1958-59.

The total registration for the 2-day Annual Meeting was 141. The local arrangements were planned and managed by C. M. Ax, a Council member representing American Society of Civil Engineers (ASCE). A program of luncheon and dinner speakers and panel sessions was presented for interested visitors from the colleges and for Participating Society members.

Dean G. A. Hawkins of the Engineering School of Purdue University presented a preview of the returns from a comprehensive questionnaire survey of Purdue engineering graduates beginning with the class of 1911. Nearly 400 responses were received and are in the process of tabulation and interpretation. Questions were designed to review the educational and professional experiences of the graduate and elicit judgments and opinions on the basis of which the University's educational program can be reevaluated. A full report on the study will be released for publication early in 1959.

The Annual Dinner, concluding the first day's program, featured an inspirational address by Dean C. L. Wilson of the Missouri School of Mines and Metallurgy at Rolla. Dean Wilson's topic was "The Road to Survival." The second day luncheon was addressed by Dr. G. E. Mowrer, director of guidance of the St. Louis Public Schools. Dr. Mowrer presented the newly inaugurated St. Louis plan for classifying and teaching students in the primary and secondary schools according to ability and interests. Each group of students is given a curriculum and quantity and level of work suited to its scholastic capacity and educational objectives.

The Education and Accreditation Committee presented for the assembled meeting a dramatic sketch to illustrate how the curriculum inspection procedure is carried out in practice by a visiting committee. Meetings of the "Visiting Committee" and interviews with "faculty" of "Hypothetical University" were conducted to show how the objectives and procedures of accreditation are applied in practice. Realism was heightened by supplying the audience with complete questionnaires as submitted by the fictitious, but typical "Hypothetical University"

The final session was in the form of an Open Council Meeting given over to the reports of the eight major ECPD committees. These reports will be a part of the "26th Annual Report of ECPD" for the year ending September 30, 1958 which will be available in December 1958. Copies will be distributed to the Board of Directors and the immediately concerned committees of AIEE. Members of AIEE can purchase copies at $1.00 each by addressing an order to the Engineers' Council for Professional Development, 29 W. 39th St., New York 18, N. Y.

F. C. Lindvall

G. H. O'Sullivan

P. L. Alger

S. L. Marras

W. D. Cannon Receives 1958 F. E. d'Humy Medal

W. P. Marshall, president of Western Union, recently presented to W. D. Cannon (F '54) the 1958 F. E. d'Humy Medal for scientific research resulting in important technical advances in the nation's communications.

Presentation of the bronze medallion, a certificate, and honorarium was made to Mr. Cannon, a radio–wire transmission research engineer, at a ceremony in the Western Union Auditorium. Hundreds of engineering, research, and scientific workers of Western Union and other companies attended.

"Mr. Cannon has made possible many of our most important advances," Mr. Marshall said, "in the development of high-speed electronic circuits used in our landline and cable operations. To mention only one of these, his invention of distortion correcting methods on electrical circuits has made possible the rapid growth in the high-speed handling of data over our private wire systems, interconnecting modern business machines and computers. Through his scientific work, he has helped to make our electronic carrier, radio beam, and cable operations as dependable, fast and efficient as they are today."

Mr. Cannon was responsible for Western Union's earth current neutralizing system and its power interference correcting method. He contributed to the development of submarine cable amplifiers which multiply the capacity of transatlantic cables, and is credited with inventions important in the modulation, amplification, and instrumentation of electronic circuitry.

Chairman H. P. Corwith, Western Union vice-president in charge of development and research, introduced the speakers, who were: E. F. Sanger, director of public relations; Albert Boggs, assistant to radio–wire transmission engineer; and F. B. Bramhall, automation engineer of the telegraph company.

A native of Delaware, Mr. Cannon received his B.S. degree at the University of Delaware before enlisting in the Signal Corps in 1918. He received an M.S. degree at the University of Illinois in 1921, and has since been engaged in Western Union engineering and research work. He is a member of the AIEE Board of Examiners.

W. P. MARSHALL *(right)*, **president of Western Union, presents F. E. d'Humy Medal to W. D. Cannon** *(left)* **for scientific research resulting in important technical advances in the nation's communications.**

Electrical Engineers Hear Talk on New Drive Unit

The Northeastern Wisconsin Section of AIEE held its first general meeting of the season at the Menasha, Wisconsin Hotel on October 2. R. A. Thomas, electrical engineer of General Electric Company (GE), Waynesboro, Va., explained the principles of GE's new constant current speed control of d-c motors for the variable speed drive industry. The speaker discussed the benefits of this new drive and its significance in aiding automation of the industry. He described these as: stepped up production, more versatile machines, reduced waste, simplified operation, and better products. The meeting was conducted by AIEE Chairman W. L. Sykes, chief electrical engineer of Miller Electric Manufacturing Company of Appleton. Approximately 72 electrical engineers representing 7 cities in the Fox Valley area attended the Thursday evening dinner meeting.

Outstanding Young Engineers Are Honored by Eta Kappa Nu

Dr. M. R. Currie of Pacific Palisades, Calif., has been named the Outstanding Young Electrical Engineer of 1958 in the annual nation-wide talent search conducted by Eta Kappa Nu, national electrical engineering honor society. J. H. Craig, chairman of the Award Organization Committee of Eta Kappa Nu, also announced that Dr. D. A. Buck of North Wilmington, Mass., received an honorable mention award in the national competition. The 1958 competition is the 23rd in the series which began in 1936. Formal presentation of the awards will be made at a banquet in the Governor Clinton Hotel, 7th Ave. and 31st St., to be held during the Winter General Meeting of the AIEE in New York, N. Y., on February 2, 1959. C. H. Linder, vice-president, General Electric Company, will make the principal address. Reservations inquiries may be sent to W. Levidow, Bell Telephone Laboratories, Whippany, N. J.

At 31 years of age, the 1958 Outstanding Young Electrical Engineer has already compiled a remarkable list of scientific and engineering accomplishments. He is credited with a major technical breakthrough in connection with noise in microwave tubes which has already made possible more than twice the sensitivity heretofore attainable in microwave receivers such as are used in radar and high-frequency relay systems. Dr. Currie has been a nationally recognized contributor to the microwave research field since shortly after his graduation from the University of California at Berkeley in 1949. His principal technical contributions have been in the area of low-noise electron guns and backward-wave oscillator development. He has published and presented a large number of technical papers in connection with his research and has applied for more than a dozen

AMONG those attending the Northeastern Wisconsin Section's first general meeting were: *(seated, left to right)* **C. A. Lens, Westinghouse Electric Corporation, Appleton, Wis.; R. A. Thomas, General Electric Company, Waynesboro, Va.; W. L. Sykes, Miller Electric Mfg. Company, Appleton, Wis.;** *(standing)* **Arthur Fitzner, Giddings and Lewis Company, Fond du Lac, Wis.**

patents of which about half have already been issued.

After receiving the A.B. degree in physics in 1949, he went on for the M.S. and Ph.D degrees in electrical engineering at the University of California, receiving these in 1952 and 1954, respectively. He joined the Research Laboratories of the Hughes Aircraft Company in 1954 as a project engineer and since 1957 he has been co-head of the microwave tube department.

Dr. Currie has not limited his creative activities to technical matters. He has participated actively in community activities both in the Berkeley area while at the University of California, and more recently in Los Angeles and environs since his association with Hughes. Perhaps his most striking accomplishment in this field occurred in 1956-57 when he organized a team of scientists and engineers to furnish lectures and demonstrations to high school students in the Los Angeles area in order to inspire them to follow technological and scientific careers. The notable success of his original team has led directly to the formation of the Southern California Industry–Education Council which now has more than 20 demonstration-lecture teams for this purpose acting in the Los Angeles area. The activity has already spread to metropolitan centers in other parts of the country.

Dr. D. A. Buck, recipient of the 1958 honorable mention citation is also 31 years of age. A native of San Francisco, Calif., he was graduated from the University of Washington as an electrical engineering major in 1948. He was subsequently awarded the M.S. and Sc.D. degrees from the Massachusetts Institute of Technology in 1952 and 1958. At present, he is serving as assistant professor of electrical engineering at the latter institution.

Dr. Buck's greatest technical contributions have been made in connection with the engineering application of low-temperature physics. His invention of the cryotron—a low-temperature electronic switch based on the effects of magnetic fields on superconductivity at liquid helium temperatures—has touched off large-scale engineering programs to exploit the properties of components operating in low-temperature environments. In 1957, he was awarded the Browder J. Thompson Memorial Prize of the Institute of Radio Engineers for his paper on the cryotron.

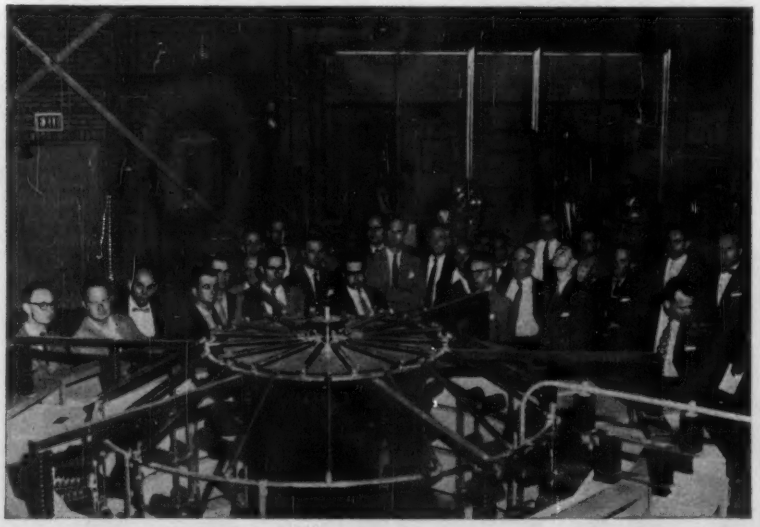
The honorable mention recipient has played a dynamic part in community affairs, having been active in a variety of service roles for almost a third of his young life. A large part of his efforts have been expended in working with young people. He has taught Sunday School, served as a scoutmaster for more than six years, and at the present time is chairman of the Wilmington, Mass., School Committee. In the latter post and as a Committee member since 1956, his efforts have produced significant changes in the effectiveness of this local group.

The Eta Kappa Nu recognition of the outstanding young electrical engineer is intended to emphasize among electrical engineers that their service to mankind is manifested not only by achievements in purely technical pursuits but in a variety of ways. It holds that an education based upon the acquisition of technical knowledge and the development of logical methods of thinking should fit the engineer to achieve a substantial degree of success in many lines of endeavor. Eligible for the award is any man who on May 1 of the year has been graduated not more than 10 years from a regular course in electrical engineering from an American college or university and who is not more than 35 years of age. Selection is made on the basis of the candidate's record of achievement in his chosen work; his service in behalf of his community, state, or nation; his cultural or aesthetic development; and for his professional activities.

Eta Kappa Nu, the sponsor of the annual award, is the national electrical engineering honor society founded at the University of Illinois in 1904. The organization has more than 28,000 members, 71 college and 12 alumni chapters in the principal cities of the United States.

Selection of this year's recognition winner and honorable mention recipient was made by a Jury of Award consisting of the following engineering leaders: Chairman, C. H. Linder, vice-president, General Electric Company; Larry Dwon, president Eta Kappa Nu, American Electric Power Service Corp.; A. N. Goldsmith, consulting engineer; L. F. Hickernell, President, AIEE, Anaconda Wire and Cable Co.; J. A. Hutcheson, vice-president Westinghouse Electric Corporation.; C. T. Koerner, past president Eta Kappa Nu, American Telephone and Telegraph Co.; Haraden Pratt, secretary, Institute of Radio Engineers Dulaex Corp.; R. B. Shank, vice-president, Hughes Aircraft Co.; and G. J. Taylor, president, Illuminating Engineering Society, Daybrite Lighting, Inc.

To assist the Jury of Award in their deliberations, each year the nominations for the Outstanding Young Electrical Engineer are given a preliminary processing and evaluation by the Eta Kappa Nu Award Organization Committee. This group arranges for collection of references and other supporting data of use to the Jury of Award in the final judging. Every effort is made to secure nominations on a nation-wide basis, and this year the records of approximately 100 candidates representing all the geographical areas of major engineering activity in the country were examined by the Committee. The Committee membership for 1958 under the chairmanship of J. H. Craig included Robin Beach, Larry Dwon, J. E. Farley, W. B. Groth, N. S. Hibshman, C. T. Koerner, E. S. Lee, B. F. Lewis, J. M. Montstream, J. H. Mulligan, Jr., and R. I. Wilkinson.



A GROUP OF AIEE MEMBERS inspect a surge-current generator at Hubbard and Company's new research laboratory during an inspection trip sponsored by the Power Group Committee of the AIEE Chicago Section.

Chicago Section Members Visit Research Laboratory

The Power Group Committee of the AIEE Chicago Section opened the 1958-59 year of Section activities with an inspection trip to Hubbard and Company's new research laboratory that is located just southwest of Chicago. The trip was limited to 100 people but shortly after it was announced it became apparent that many more desired to attend. Therefore, the trip was extended to a second night to accommodate a total of almost 200 for both nights.

The laboratory inspection trips were preceded by dinner and a sponsored cocktail party at a famous restaurant near the laboratory.

The laboratory represents a consolidation of Hubbard and Company's electrical and mechanical research and development facilities which had previously been located throughout the United States. This includes a complete model shop.

The laboratory is supplied with 138 kv from the Commonwealth Edison Company system. Hubbard's supply trans-

former is designed with numerous taps so that a large variety of testing voltage and currents are available. Short-circuit currents up to 25,000 amps can be produced, and 60-cycle distribution voltages are available in 1.5-kv increments from 1.5 kv to 18 kv. The switching facilities are ingeniously interlocked and monitored with photoelectric devices.

The laboratory is equipped with 5 impulse generators the largest of which is rated 3.2 million volts. In addition, a surge current generator that theoretically can produce 300,000 amperes is available for testing electrical equipment.

Special photographic equipment is used at the laboratory for ultrahigh-speed filming of the testing. A 200,000 foot candle flash is used for some of the work.

The Chicago Section members attending were divided into groups to witness demonstrations of high-voltage and high-current surge equipment. Also demonstrated were the facilities for testing electrical distribution equipment under system fault conditons. Static mechanical tests on pole line hardware and street light standards were inspected. Although there was a size limitation in the control room, a closed circuit television set gave everyone an opportunity to receive a detailed explanation of the major control console. A movie that was made on the site, showing the destruction testing of a distribution cutout, was of interest to all.

The motto of the laboratory is, "These facilities are dedicated to the engineering profession and to those it serves, for the continued improvement of electrical products and service in the home and in industry."

Engineers Honored by The Franklin Institute

Several electrical engineers and AIEE members were among the men honored by The Franklin Institute at its 32nd annual Medal Day ceremonies held October 15, 1958.

Howard N. Potts Medals were awarded to two electrical engineers, Dr. Emanuel Rosenberg of Bogotá, Colombia, South America, who invented the cross-field generator, and W. N. Goodwin, Jr. (F '13), of New Hope, Pa., who invented the photoelectric exposure meter.

Dr. Rosenberg was honored for ". . . his conception of a fundamentally new principle for deriving electrical current from a rotating machine and for his solution of the many technical problems related to the development of the cross-field generator." The generator, invented in 1904 for train lighting, was adapted by Dr. Rosenberg in 1925 for electric arc welding. Modifications by J. L. Woodbridge, Alexanderson, and others created an extensive field of application for control of electric and mechanical machinery. The principle of the generator has been utilized in other fields including that of guided missiles. Dr. Rosenberg has been issued many patents and is author of numerous papers and three books, "Electrical Engineering," "The Cross-Field Generator," and "An Engineer's Career."

Executive Committee in Session

ONE OF THE FIRST 1958-59 Executive Committee meetings for the AIEE Pittsfield Section was attended by: (*left to right*) J. A. Van Lund, member-at-large; Russell King, chairman of the Vermont Subsection; B. A. Cogbill, junior past chairman; A. F. Rohlfs, member-at-large; Sven Osthagen, vice-president for AIEE District No. 12; W. W. Green, chairman of the Pittsfield Section; J. O. Sweeney, vice-chairman; W. F. Dripps, secretary-treasurer.

Members Plan Section Activities

Photo by Morris Peck

MEMBERS OF THE EXECUTIVE COMMITTEE of the Ithaca Section of AIEE met on October 10, 1958, at Cornell University to plan activities for the 1958-59 season. Seated (*left to right*) are A. O. Kenyon, Section chairman, and Simpson Linke, secretary. Standing (*left to right*) are R. E. Markle, chairman, Technical Discussion Group Committee, and C. J. Fitch, past Section chairman and director of the local New Building Fund Drive.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

Born in Vienna, Austria, November 28, 1872, Dr. Rosenberg was graduated from the Vienna Technical University in 1895 as a mechanical and electrical engineer. After serving in several jobs, Dr. Rosenberg in 1917 became director of the Elin works in Weiz, Austria, where he pioneered in the electric arc-welding field. Dr. Rosenberg left the Elin Company in 1938.

Mr. Goodwin was honored for ". . . his many contributions to the field of electrical measuring instruments of which the thermal ammeter, the vacuum tube tester, and the rectifier instrument are examples, and in particular for his work on photoelectric exposure meters and establishing a scale for film speeds." Author of five papers, Mr. Goodwin has been issued 16 patents. His rectifier-type milliammeter is widely used today for measurement of voice frequency signals, from the control instruments in the long-lines carrying radio programs from coast to coast to the instruments on television programs, popularly known as "applausemeters."

Born on October 10, 1876, in Philadelphia, Mr. Goodwin was graduated from the University of Pennsylvania in 1898. He joined the Weston Electrical Instrument Corporation with which he spent his entire engineering career. After serving as chief engineer, Mr. Goodwin became vice-president in charge of engineering in 1939. He retired on December 31, 1946, but was retained by Weston Corporation for some years as a consultant on special engineering problems because of his unique ability in solving network and circuit problems involving higher mathematics and problems related to heat flow.

The Stuart Ballantine Medal this year was presented to Dr. H. T. Friis (F '41), of Rumson, N. J., the electrical engineer who set up the receivers in England for the radio-telephone system which connected America and Europe in 1923. A consulting engineer, formerly director of research in high frequency and electronics for Bell Telephone Laboratories, Dr. Friis was honored for ". . . his many important contributions to the science of radio communications during a lifetime of consistently productive research in this field, through which this science has been so notably advanced." One of his important contributions was the decreasing of noise in short-wave receivers, resulting in better reception. This contribution made possible Jansky's discovery of relatively weak radio signals emanating from interstellar space which, in turn, developed into the important new science of radio astronomy.

Dr. Friis was born in Naestved, Denmark, on February 22, 1893. He received his degree of electrical engineer from the Royal Technical College, Copenhagen, in 1916. He came to the United States in 1919 on a fellowship from the American-Scandinavian Foundation to study at Columbia University. That year, he joined the Research Division of Western Electric Company's engineering department which became the Bell Telephone Laboratories in 1925. Dr. Friis spent 38 years with the Laboratories before retiring in March 1958. He has had 25 patents issued to him, 10 jointly, and with Dr. S. A. Schelkunoff has written a book, "Antennas: Theory and Practice."

The Certificate of Merit was awarded to the scientist, Dr. Harold Lyons (M '47), head of the atomic physics department of Hughes Aircraft Company, Culver City, Calif., who developed the atomic clock. Dr. Lyons has had seven patents issued to him for: the atomic clock, a double pulse oscillator, a controllable pulse generator, a method and means for generating multiline sweep patterns, a step-wave generator, a counter frequency divider without time delay, and a collapsible multicorner reflector for uhf radiant energy.

Dr. Lyons was born February 16, 1913, in Buffalo, N. Y. He was graduated magna cum laude from the University of Buffalo in 1933 with a B.A. degree in physics. He received his M.A. degree and his Ph.D degree (in 1939) from the University of Michigan. Dr. Lyons spent 14 years with the National Bureau of Standards where he developed the atomic clock in 1948. Dr. Lyons joined Hughes Aircraft Company in 1955. He directs the organization and development of research programs in atomic and molecular physics.

No Price Change for IEE Publications

The Institution of Electrical Engineers (IEE) has announced that there will be no changes in the annual subscription rates to the *Journal* and the *Proceedings* of the IEE and "Science Abstracts" for the year 1959. A letter to this effect has been sent to each individual subscriber. Following are the reduced rates of subscription available to AIEE members.

Journal	£1.10s. 0d
Proceedings	
Part A (Power Engineering)	1.17s. 6d
Part B (Radio and Electronic Engineering)	1.17s. 6d
Part C (Collected Monographs)	18s. 9d
Journal and Proceeding Parts A, B, and C (combined subscription)	6. 0s. 0d
"Science Abstracts"	
Section A (Physics)	4.10s. 0d
Section B (Electrical Engineering)	3.15s. 0d
Sections A and B (combined subscription)	7.10s. 0d

AIEE members should send new orders to: N. S. Hibshman, Secretary, AIEE, 33 W. 39th St., New York 18, N. Y., together with remittance.

J. H. Foote Receives Plaque from AIEE Michigan Section

J. H. Foote, president and chief engineer of Commonwealth Associates, Inc., of Jackson, Mich., was presented a plaque by the AIEE in acknowledgment of his services as a vice-president of the Institute during 1956-58.

The presentation was made by J. W. Eakins, chairman of the Michigan Section of AIEE at its October 7, 1958, Section Meeting held at The Country Club of Jackson.

Mr. Foote's duties as vice-president included visiting local sections, subsections, and student branches in AIEE District No. 5 and attending associated meetings of the District Executive Committees and Board of Directors. In carrying out these duties, he made over 35 visits with executive committees and members of subsections and about 25 visits to the various

J. H. FOOTE (*left*), president and chief engineer of Commonwealth Associates, Inc., Jackson, Mich., receives a plaque in acknowledgment of his services as an AIEE vice-president from J. W. Eakins, chairman of the Michigan Section.

student branches. His district included local sections and colleges in Michigan, North Dakota, South Dakota, Iowa, Minnesota, Wisconsin, Ohio, Indiana, and Illinois.

Dr. Engstrom Addresses AIEE Fort Wayne Section

The development of faith, wisdom, and tolerance to levels more nearly the equivalent of our technical prowess is the great challenge facing mankind today, Dr. E. W. Engstrom, senior executive vice-president of the Radio Corporation of America, said during his address at the 50th Anniversary dinner of the Fort Wayne Section of AIEE.

"We can develop no electronic, electrical, or mechanical substitutes for these qualities," he said, "yet unless they are cultivated in far greater measure than they appear today, our greatest scientific and engineering achievements may well turn out to be nothing more than invitations to catastrophe."

Current scientific progress "resulting from application of the human intellect," he said, "shows uncomfortable signs of being too much for the human spirit."

Surveying scientific and engineering progress in the past 50 years, Dr. Engstrom referred to the technology of 1908 as "a remarkable mingling of the primitive and the prophetic," opening a new era of technical advance which has faced the engineer with "many challenges and heavy responsibilities."

Pointing to recent achievements in nuclear power, electronic techniques, and missile and satellite development, he said:

"Only 50 years ago, the engineer was expected to encompass all, or nearly all, of the knowledge pertaining to his broad field. . . . His successful fulfillment of his responsibilities can be read between the lines of any history recounting the growth of American industrial strength through the application of electric power during the first part of this century.

"Today, our technology is demanding complete systems to perform ever more sophisticated functions in industry and defense. Often, these systems require the application of principles that have advanced only recently beyond the stage of theory. Furthermore, they represent an accumulation of knowledge from many diverse fields. Thus, the basic knowledge that must be applied in their development is so extensive and so diverse that only a fraction can be embraced by any one individual."

The response to this new condition, he added, is the development of the scientist–engineer team and the widespread practice of systems engineering, in which the engineer today has "an even broader scope for his activities," and in which "his skills will be most effectively utilized and directed toward principal objectives."

Dr. Engstrom predicted continuing technological advance in the future, but added:

"How mankind will fare with the accumulating results of this material progress is far less certain. This will depend upon how his sights are aligned now and in the future. . . .

"Science and engineering will provide the means for a golden age if their results are directed to the benefit of mankind. At the same time, science and engineering will provide the means for utter destruction if their results are directed to selfish, greedy, and depraved ends. These are the choices. . . . The problem will not disappear by itself. It is ours to wrestle with today, and it may be ours to wrestle with for a long time to come."

CELEBRATING the 50th anniversary of the Fort Wayne Section of AIEE are: *(left to right)* R. B. Gear, AIEE vice-president for District No. 5; Dr. E. W. Engstrom, senior executive vice-president, Radio Corporation of America, featured speaker at the anniversary dinner; M. L. Miller, chairman of the Anniversary Committee; and B. L. Biega, chairman of the Section.

AIEE Nebraska Section Meeting

Walter S. Craig Photography

SHOWN AT THE AIEE NEBRASKA SECTION'S first meeting of the 1958-59 season are: *(left to right)* M. I. Risley, Section chairman; P. H. Henson, Section secretary-treasurer; A. G. Johnson, District No. 6 vice-president; W. A. Richardson, United Building Fund chairman and last season's Section chairman; C. S. Roadhouse, District No. 6 secretary; and P. T. Baird, Section vice-president. During the dinner meeting, Mr. Johnson presented Mr. Richardson with a past-chairman's certificate and pin.

AIEE Fellow Diploma Presented

L. R. SELLERS (*center*) **receives his Fellow Diploma during the September 9 meeting of the East Tennessee Section of the AIEE. Among those at the presentation were L. E. Marshall** (*left*)**, chairman of the Section; and William Paynter, Jr.** (*right*)**, chairman of the Transfers Committee.**

AIEE FELLOWS ELECTED

Board of Directors Meeting, August 21, 1958

Carl Henry Bjorquist (M '43), assistant chief of design, Bonneville Power Administration, Portland, Oreg., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to standards for and tests of high-voltage power system equipment." Mr. Bjorquist was born in Beaver Hill, Oreg., June 21, 1904. He received a B.S. degree in electrical engineering from Oregon State College in 1926, and while there worked on high voltage insulator research under past AIEE president F. O. McMillan. He began his engineering career in 1926 in the Westinghouse Graduate Student Course and Engineering School. Upon completion of this training, he served in several assignments both in the factory and field as a motor design and application engineer. From 1931 to 1935, he was associated with the Beeson Engineering Company of Los Angeles, Calif., as a design and application engineer on small steam and diesel power plants. In the latter part of 1935, he joined the Bureau of Power and Light of the City of Los Angeles on the cut-over of the system and customer facilities from 50 to 60 cycles and was in charge of the group responsible for the redesign of customers' electrical equipment requiring changes and for the set up of many unique methods and procedures for rapid engineering and handling of a wide variety of problems associated with such a project. In 1938, he became associated with the Bonneville Power Administration where he has held positions of chief of materials and inspection, chief of design during the war years, and assistant chief of design since 1951. He has been an active member of the AIEE Transformers Committee and its Dielectric Tests Subcommittee since 1951; has served on various working groups and subcommittees of this Committee including the organization and chairmanship for three years of its West Coast Subcommittee. He has also been a member of the Rotating Machinery Committee (1954-58) and its Synchronous Machinery Subcommittee. At Oregon State, he became a member of Eta Kappa Nu, Tau Beta Pi, and Sigma Tau.

C. H. Bjorquist

The Ellis Studio

Albert Hansen, Jr.

D. D. MacCarthy

Albert Hansen, Jr. (AM '37, M '45), manager, d-c advance engineering, low voltage switchgear department, General Electric Company, Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to design and improvement of electric instruments." Mr. Hansen was born in Perth Amboy, N. J., on January 10, 1916. He graduated from Pratt Institute in industrial electrical engineering in 1936. He then joined the General Electric Company Test Program and has been with that company for his whole industrial career. From 1937 to November 1955, he held various positions in the meter and instrument department at Lynn, Mass., the last of which was manager, advance engineering. During this period, he was engaged primarily in the development of instruments and watthour meters. As a result of this work, 18 United States patents have been issued in his name covering a wide range of fundamental contributions to the measurement art. In 1948, he was presented the Charles A. Coffin award for his contribution to the General Electric *150* watt-hour meter. His primary contribution was the magnetic suspension bearing system. In November 1955, he was appointed manager, engineering of the General Electric rectifier department and until August 1958 was located at the Lynchburg, Va., headquarters. His present assignment is manager, d-c advance engineering, low voltage switchgear department, with headquarters at Philadelphia. Mr. Hansen is a member of the American Society of Mechanical Engineers and the National Society of Professional Engineers. He is a registered professional engineer in the State of Massachusetts. He has served on the following AIEE Committees: Industrial Control (1953-55), Instruments and Measurements (1955-56), and Semiconductor-Metallic Rectifiers (1957-58).

Donnell D. MacCarthy (AM '28, M '48), manager of voltage regulator engineering, power transformer department, General Electric Company, Pittsfield, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to overvoltage protective apparatus for electric power systems." Mr. MacCarthy was born in Raleigh, N. C., on January 31, 1905. He graduated from Cornell University with an electrical engineering degree in 1926. For the next four years, he was an instructor in the school of electrical engineering at Cornell and a student in the graduate school. While in college, he was elected to Eta Kappa Nu, Tau Beta Pi, and Phi Kappa Phi. He received a master's degree in electrical engineering in 1930. This same year he joined General Electric in Pittsfield, Mass., as a development engineer working on lightning arresters. Later he became a section engineer in charge of this work. In 1947, he transferred to the power transformer department to organize the advance product engineering component. In 1952, he was appointed to his present position of manager of voltage regulator engineering. This component is responsible for the development and design of step and induction voltage regulators. His AIEE activities include heading several committees of the Pittsfield Section and serv-

ing as chairman of the Section. He is the author of several AIEE papers and holds several patents dealing with lightning protection. Mr. MacCarthy is a member of the Massachusetts Society of Professional Engineers.

Theodore W. Stringfield (AM '36, M '46), head, electronics and communications design, Bonneville Power Administration, Portland, Oreg., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to power system communications and protection." Mr. Stringfield was born in New York, N. Y., on March 28, 1909. He received his E.E. degree from Rensselaer Polytechnic Institute (RPI) in 1932 and the M.E.E. degree from the Polytechnic Institute of Brooklyn in 1935 where he also continued advanced study in 1936 and 1937. After graduation from RPI, he was employed by the Consolidated Edison Company of New York from 1933 to 1939 in test engineering. In 1939, he joined the Bonneville Power Administration where he prepared specifications for high-voltage transmission line and substation equipment and also performed factory inspection of similar equipment. He conducted radio noise influence investigations at the Ryan High-Voltage Laboratory at Stanford University. In 1942, he transferred to the Navy Department and served as civilian construction engineer for the U. S. Navy in charge of electrical and mechanical construction of the U. S. Naval Ordance Plant at Pocatello, Idaho, and the Naval Gun Proving Range at Arco, Idaho. In September of 1943, he entered active duty as a Lieutenant (jg) and after completing radar training at Bowdoin College and Massachusetts Institute of Technology (MIT), was assigned as a special project engineer to the MIT Radiation Laboratory. In 1946, he was separated from the U. S. Navy and returned to Bonneville Power Administration where he is presently head of electronics and communications design. Mr. Stringfield has contributed to AIEE and to electrical magazines on transmission line fault location and microwave radio communication. He holds patents in the field of transmission line fault location. He has served on the AIEE Special Communication Applications Committee (1951-56) and Radio Communication Systems Committee (1955-58). He is a registered professional engineer in the State of Oregon.

Robert Rhamy Wagstaff (AM '35, M '46), chief engineer, United Engineers & Constructors, Inc., Philadelphia, Pa., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to design and execution of large power projects." Mr. Wagstaff was born on October 16, 1912, in Springfield, Mo. He attended Drury College and received his B.S. degree in E.E. from the University of Arkansas in 1934. He did graduate work at Massachusetts Institute of Technology where he received a master's degree in E.E. in 1937. During 1934 to 1936, he was engaged in test work on electrical precipitators for American Smelting and Refining Company at Tacoma, Wash. In 1937, he joined United Engineers & Constructors and was employed as an electrical field engineer and design engineer on several large power and chemical projects. During World War II, Mr. Wagstaff served with the U. S. Navy as a Lieutenant in the Electronics Division of the Bureau of Ships in Washington, D. C. Returning to United Engineers & Constructors in 1946, he was successively assistant electrical engineer, electrical engineer, and supervising engineer. He was responsible for reports, engineering, and design on numerous generating stations, substations, transmission lines, testing laboratories, steel and textile mills, and chemical plants. In 1956, he was appointed chief engineer. Mr. Wagstaff is a member of the American Society of Mechanical Engineers, Association of Iron and Steel Engineers, Engineers' Club of Philadelphia, and the National Society of Professional Engineers. He serves on the Committee on Electric Switching and Switchgear of the Association of Edison Illuminating Companies (AEIC), the Electrical System and Equipment Committee of the Edison Electric Institute (EEI), and the AEIC-EEI-NEMA (National Electrical Manufacturers Association) Joint Committee on Power Circuit Breakers. He serves as an electric light and power representative on ASA C-37 Committee on Switchgear and ASA C-6 Committee on Terminal Markings. He has been active on many committees and as a manager of the Philadelphia Section of AIEE. He is a registered professional engineer in 14 states.

T. W. Stringfield

R. R. Wagstaff

M. S. Wilson

Myron S. Wilson (AM '26, M '43), manager of engineering, electrical instruments, instrument department, General Electric Company, Lynn, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the design of electrical measuring instruments especially by the improvement in accuracy of current transformers." Mr. Wilson was born in Spencer, Mass., on July 21, 1899. He graduated from the General Electric Tool and Diemaking Apprentice Course in 1920 and from the Electrical Engineering Course, Lowell Institute, Cambridge, Mass., in 1924. His entire career has been with the General Electric Company at Lynn., Mass. From 1924 to 1928, he worked on the development and design of precision test equipment to accurately determine the ratio and phase angle errors of instrument transformers used for the measurement of current and voltage. During 1928-29, he developed a means of compensating for the ratio and phase angle errors of current transformers which substantially reduced these errors without the use of high cost magnetic materials. He received the General Electric Coffin Award in 1930 for this invention. From 1930 to 1940, he was responsible for the development and design of various indicating instruments for the measurement of electrical quantities. Particularly noteworthy was a new line of long-scale switchboard type instruments which were the first of this type to be manufactured in this country and were used on all types of United States fighting craft during and since World War II. From 1940 to the present, he has been responsible for the development and design of numerous instruments for the measurement or recording of all electrical quantities. Mr. Wilson has served in various offices of the Lynn Section of AIEE and has been a member of the AIEE Indicating and Integrating Instruments Committee since 1956. He is a member of the Massachusetts Society of Professional Engineers and the National Electrical Manufacturers Association. He has obtained several patents on instruments and instrument transformers, and has written several technical papers.

Board of Directors Meeting, September 30, 1958

C. Russell Mason (AM '37, M '45), application engineer, user industries sales department, General Electric Company, Schenectady, N. Y., has been transferred to the grade of Fellow in the AIEE "for contributions to development and application of power-system protective apparatus." Mr. Mason was born in Meriden, Conn., on October 26, 1905. He received his B.S. degree in E.E. from the Harvard Engineering School in 1928. Upon graduating, he was employed as a test engineer at General Electric. Following the test course, he became a relay design and application engineer at the General Electric switchgear plant at Philadelphia, Pa. In 1936, he transferred to the central station engineering department as a relay application engineer. For a short time after the start of World War II, he contacted the U.S. Navy and the Bureau of Yards and Docks regarding the design of naval power-system

C. R. Mason

Warren Kay Vantine Studio
W.C. White

installations. During the rest of the war period, he was a design engineer and group leader in the voltage regulator department, concerned with the design and production of relays for war aircraft. Following the war, Mr. Mason returned to the central station engineering department (now Electric Utility Engineering Section) where he continued in relay application work. He has been active in educational programs at General Electric, teaching yearly courses in protective relaying and electric utility systems and practices. In 1953, he was a Union College instructor in a graduate course in protective relaying. He is the author of four AIEE papers and numerous articles for General Electric publications. In 1956, his book "The Art and Science of Protective Relaying" was published by John Wiley and Sons, New York, N. Y. He holds 9 United States patents on relay and regulator devices and systems.

William C. White (AM' 37, M '42), provost and vice-president of Northeastern University, Boston, Mass., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to the education of engineers." Dr. White was born on June 20, 1902, in Dorchester, Mass. He was graduated from Eastern Radio Institute in 1920 and went on to study at Northeastern where he was granted a B.E.E. degree in 1925. In 1931, he received his Ed.M. degree from Boston University. Meanwhile, he had joined the Northeastern faculty in 1926 as instructor in English and alumni secretary. He has since served the University in the capacity of assistant director of student activities, instructor in co-operative employment co-ordination, secretary of the faculty, professor of education, dean of the College of Engineering, director of Day Colleges, executive council member, and dean of administration. In 1952, he was awarded an honorary doctor of education degree by the University and the following year was appointed its vice-president. He was named provost in 1957. Dr. White is a member of the American Society for Engineering Education, and has served on its General Council and on numerous committees. He is past president of Engineering Societies of New England; member of the Fellowship Board of Tau Beta Pi; member of Eta Kappa Nu; past vice-president, Emergency Planning and Research Bureau, Boston; past chairman of Region I of Engineers' Council for Professional Development, Subcommittee on Technical Institutes; and member of the National Society of College Teachers of Education. During World War II, he served as Regional Advisor, U. S. Office on Education: Engineering Science and Management War Training Program. Dr. White is a registered professional engineer in Massachusetts, and is widely known throughout the United States for his leadership in professional engineering as well as educational circles. He is the author of numerous technical papers and articles in professional magazines dealing with subjects ranging from grading practices at Northeastern University, to engineering education, to technical training for war industries. Dr. White has served on the AIEE Members-for-Life Fund Committee (1954-57) and Professional Development and Recognition Department (1956-59).

AIEE PERSONALITIES

H. A. Affel (AM '18, F '41, Member for Life), assistant vice-president in the switching and transmission development department, Bell Telephone Laboratories, Inc., has retired after a 42-year career with the Bell System. Mr. Affel, who is co-inventor of the coaxial cable system, holds 123 patents on wire and radio systems. He is a Fellow of the Institute of Radio Engineers, Acoustical Society of America, and American Association for the Advancement of Science. He received a Modern Pioneer Award from the National Association of Manufacturers in 1940. Mr. Affel has served on the following AIEE Committees: Communications (1938-49, chairman 1943-45); Technical Program (1943-45, 1949-50); Standards 1943-45); Award of Institute Prizes (1943-45, 1950-52); Radio Technical Program Board (1944-48; Communication Division (1949-50, 1951-58, chairman 1953-55); Wire Communication Systems (1949-51, chairman 1949-50; Technical Operations (1953-58); Professional Development and Recognition Department (1957-59); and Professional Conduct (chairman 1957-59).

L. K. Stringham, (AM '34, F '49), vice-president in charge of engineering, The Lincoln Electric Company, Cleveland, Ohio, has been elected vice-president, research and development, Emerson Electric Manufacturing Company, St. Louis, Mo. Mr. Stringham joined Lincoln Electric after graduating from Cornell University in 1933. He pioneered in developing agglomerated fluxes for the hidden arc welding process and the equipment that made possible their application in industry. He also directed Lincoln Electric's development in the use of iron powder electrodes, and of a universal welding machine that produces both a-c and d-c welding current. Mr. Stringham has served on the AIEE Electric Welding Committee (1945-49, 1951-58).

Karl Kempf (AM '43), vice-president of the Sta-Kon Division, The Thomas & Betts Co., has been elected to the board of directors of the company.

E. H. Merdinger (AM '53), of the Bogue Electric Manufacturing Co., Paterson, N. J., has been appointed manager of the company's quality control activities. Mr. Merdinger, a graduate electrical engineer, joined the Bogue organization in 1943.

H. F. Mitchell, Jr. (M '56), director of Univac Applications, Remington Rand Univac Division, Sperry Rand Corporation, Los Angeles, Calif., has been appointed director of the management services department of the Remington Rand Univac Division, New York, N. Y. Among other important scientific functions, his group will facilitate the English language approach to electronic computer systems. Mr. Mitchell has served on the AIEE Computing Devices Committee (1956-58).

M. E. Mohr (AM '39, M '53), vice-president and director of the Control Systems Division, The Ramo-Wooldridge Corporation, Los Angeles, Calif., has been named vice-president, engineering, and will be responsible for the Control Systems Division, Communications Division, and the Electronic Instrumentation Company. The latter, a division of The Ramo-Wooldridge Corporation, is located in Denver, Colo. Mr. Mohr has served on the AIEE Computing Devices Committee (1953-55).

H. F. Wall (M '31), general superintendent, Public Lighting Commission, Detroit, Mich., has been elected to the rank of fellow in the Illuminating Engineering Society. Mr. Wall has a record of 29 years' experience in the illuminating engineering field. He is a charter member of the Engineering Society of Detroit and a member of the board of governors of the Electrical Association of Detroit. Mr. Wall has served on the AIEE Production and Application of Light Committee (1947-58) and Automatic Stations Committee (1939-41).

J. O. Campbell (AM '55), distribution apparatus manager of the central region, Westinghouse Electric Corporation, with

headquarters in Pittsburgh, Pa., has been appointed Chicago, Ill., area sales manager for the Westinghouse Apparatus Division.

W. S. Chaskin (AM '55) of the International Telephone and Telegraph Corporation (ITT) has been named laboratory director in charge of communication systems research at the Palo Alto, Calif., facilities of ITT Laboratories. Mr. Chaskin joined the ITT system in 1956 following 10 years with Lenkurt Electric Company.

Glen Iaggi (AM '50), assistant sales manager, Rectifier-Capacitor Division, Fansteel Metallurgical Corporation, North Chicago, Ill., has taken on the additional duties of railway sales promotion and supervision of railway sales agents.

J. P. Jordan (AM '42, M '52) of the General Electric Company, Syracuse, N. Y., has been appointed assistant to the president of Gulton Industries, Inc., Metuchen, N. J. Mr. Jordan will serve in the capacity of a scientific co-ordinator, responsible for technical planning on Government and company-sponsored programs. Mr. Jordan is the author of numerous technical papers including university text books. He is membership chairman of the Professional Group on Electron Devices of the Institute of Radio Engineers. He has served on the following AIEE Committees: Electronics (1945-47, 1952-58); Solid-State Devices (1955-58, chairman 1955-57); Science and Electronics Division (1955-58); Standards (1956-58); and Special Publications (1957-58).

Henry Rempt (M '48), director of the Electronics and Armament Systems Division, Lockheed Aircraft Corporation, Burbank, Calif., has been elected president of the Institute of Navigation. A registered professional engineer, Mr. Rempt is a member of the Institute of Aeronautical Sciences and a senior member of the Institute of Radio Engineers. He has served on the AIEE Air Transportation Committee (1944-58).

R. C. Wilson (AM '47, M '58), manager—marketing, distribution assemblies department, General Electric Company, Plainville, Conn., has been named manager—manufacturing and plant operations.

Z. W. Pique (M '49), manager of the capacitor department, Semiconductor Division, Texas Instruments, Inc., Dallas, Tex., has been named director of sales for the Hughes Products Group of Hughes Aircraft Company, Los Angeles, Calif.

W. D. Helm (AM '42), manager of Century Electric Company's Milwaukee (Wis.) Branch Office, has been assigned the managership of the Chicago (Ill.) Office.

William Darrah (AM '09), president of Continental Industrial Engineers, has been named vice-president of the newly created Continental Division (formerly Continental Industrial Engineers) of Lindberg Industrial Corporation, Chicago, Ill. Mr. Darrah has received the Industrial Pioneer Award from the United States Chamber of Commerce, and also holds the Trinks Award of Pioneer in Industrial Heating. He has been granted 90 patents embracing problems of heat transfer and mechanical and electrical devices.

L. W. Buechler (AM '38, M '48), chief engineer, Electric Products Division of Vickers, Inc., has been appointed the Division's new general sales manager. **J. L. Behr** (AM '54), manager of military engineering, succeeds Mr. Buechler as chief engineer. Mr. Buechler has served on the AIEE Magnetic Amplifiers Committee (1951-58) and Metallic Rectifiers Committee (1955-58).

D. G. Third (AM '56) of the Hydro-Electric Power Commission of Ontario, has been appointed commercial engineer attached to the Ontario District, Sylvania Electric (Canada) Ltd. A graduate of the University of British Columbia and RCAF veteran, Mr. Third was formerly associated with B.C. Electric.

R. C. Gorham (AM '24, F '55), professor, University of Pittsburgh, was awarded the Distinguished Service Certificate by the National Council of State Boards of Engineering Examiners (NCSBEE) at their Annual Banquet on August 22, 1958. The Board of Directors also adopted a resolution complimenting Prof. Gorham on his outstanding work for NCSBEE and the engineering profession.

OBITUARIES

Bird Lee Barns (AM '09, M '21, Member for Life), retired, Canadian General Electric Company, Ltd., Peterboro, Ont., Canada, died recently. Mr. Barns was born August 13, 1882, in Smyrna, Mich. He graduated from the University of Michigan in 1906. From 1906 to 1909, he was with the General Electric Company, after which he spent a year as an instructor in electrical engineering at the University of Michigan. From 1910 to 1912, he was employed in the electrical and hydraulic departments of Allis-Chalmers Manufacturing Company. He joined the Canadian General Electric Company in 1912. During World War I, he served in the U. S. Army in France as Captain of Engineers in the Office of the Chief of Engineers, AEF, after which he returned to the Canadian General Electric Company in Peterboro, Ont. Mr. Barns served on the AIEE Electrical Machinery Committee (1920-35).

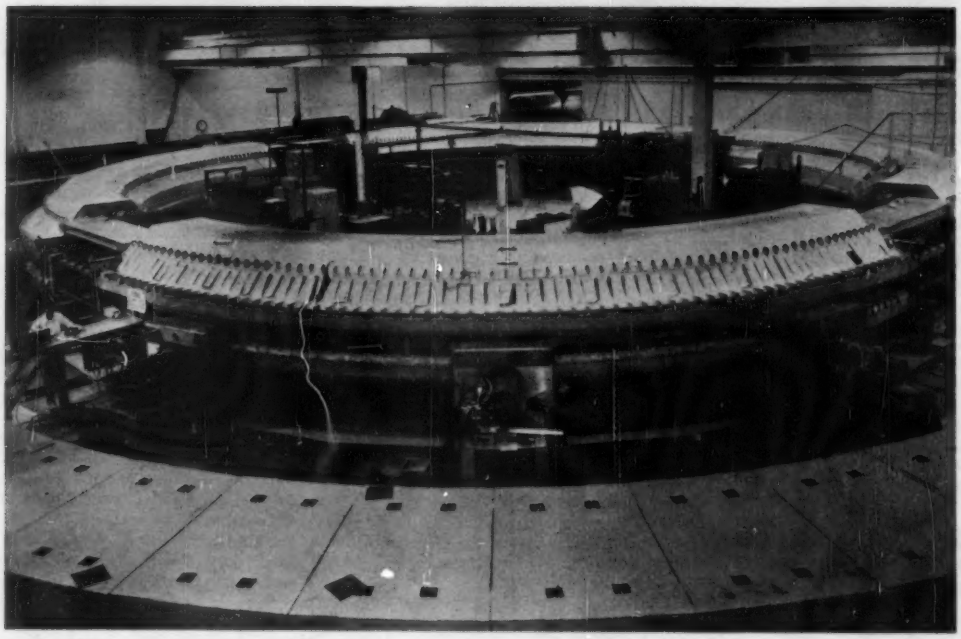
Evan R. Jones (AM '25, M '31), of Denver, Colo., died recently at the age of 56. Mr. Jones, who served as AIEE vice-president for District No. 6, 1955-57, was born in Anaconda, Colo., on February 5, 1902. He received his B.S. degree in E.E. in 1923, M.S. degree in 1924, and E.E. degree in 1928, all from the University of Colorado. In 1928, he joined the Mountain States Telephone and Telegraph Company where he had recently completed 30 years of continuous service. His last position was general plant toll circuit layout supervisor. Mr. Jones had been an active member of the Denver Section of AIEE, serving as secretary, 1947-50; vice-chairman, 1950-51; chairman, 1951-52; and on numerous Section committees. He was a member of the Institute's Wire Communications Systems Committee (1951-56) and Student Branches Committee (1956-58). Mr. Jones was a charter member of the Colorado–Wyoming Academy of Science. He was a member of the Telephone Pioneers, Colorado Engineering Council and Engineering Manpower Commission, and Tau Beta Pi.

Walter I. Slichter (AM '00, M '03, F '12, Member for Life), retired, of Schenectady, N. Y., died recently at the age of 84. Born in St. Paul, Minn., Mr. Slichter was graduated from Columbia University in 1896. Following graduation, he was employed by the General Electric Company where he worked as an associate of C. P. Steinmetz. In 1912, he joined the faculty of Columbia University, later becoming head of the electrical engineering department there. He retired in 1938. Mr. Slichter served as National Treasurer of the AIEE from 1930 to 1952. He was also manager, 1918-22, and vice-president, 1922-24. He served as member or chairman of numerous Institute Committees including the following: Board of Examiners, Editing, Educational, Co-ordination of Institute Activities, Edison Medal, Meetings and Papers, Executive, Publication, Finance, Standards, Constitution and Bylaws, Electrical Machinery, Land Transportation, and Members-for-Life Fund.

Leslie Thomas Warner (AM '20), of Sydney, N.S.W., Australia, died recently. Born in 1896, Mr. Warner was educated at Sydney Technical College. In 1916, he joined Sydney Municipal Council Electricity Department where he held various positions during his engineering career. Mr. Warner was responsible for the introduction of Busbar protection of metal clad switchgear in Sydney, and was largely responsible for the design and construction of the "B" Section Bunnerong Power Station and for the design and construction of the new Pyrmont Power Station which was recently put into service by the Electricity Commission. He was a member of the American Society of Mechanical Engineers.

Carl Whitmore (AM '18, Member for Life), retired president of the New York Telephone Co., died recently at the age of 74. Born in Oakland, Calif., in 1884, Mr. Whitmore graduated from the University of California. He joined the Bell System in 1911 as a field man with the Pacific Telephone & Telegraph Co., at San Francisco. He worked for a few years in Portland, Oreg., returning to San Francisco in 1923 as division superintendent of installation for the Western Electric Co. He went to New York in 1927 as general manager of installation for Western Electric. He was named general plant manager for the upstate area of New York Telephone Co. in 1935; vice-president and general manager of the Long Island area in 1936; and a director and vice-president in charge of personnel in 1940. In 1944, Mr. Whitmore was elected president of New York Telephone. He retired from this position in 1949 but continued as a director until 1953. Mr. Whitmore contributed much time to the New York Heart Association of which he was honorary chairman.

OF CURRENT INTEREST



CONCRETE *blocks in foreground serve as a shield against high-energy atomic rays and particles which emanate from the Cosmotron located at Brookhaven National Laboratory, Upton, N.Y. When the "doughnut," on which the man is kneeling, is in full operation, no personnel is permitted in the room except behind the shield.*

Cosmotron Cooled by Special Chiller

HOLDING PROTONS up to energies of 3 billion electron volts—more than the energy of some cosmic rays—calls for a quick, sure way to cool the magnetic holding force.

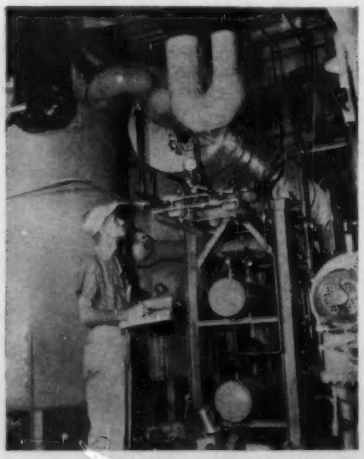
This force, produced by a 2,000-ton electromagnet at Brookhaven National Laboratory literally spins protons around a 75-foot orbital path at the rate of 3 million times per second.

The giant particle accelerator, called the Cosmotron, holds protons on an even course while a radio frequency amplifier adds 1,000 volts to the energy of the protons each time they circle the accelerator.

The large "doughnut" is the magnet of the Cosmotron. It has an inside diameter of over 60 feet and weighs 2,000 tons. The three units on the floor next to the magnet are pumps, to evacuate the vacuum chamber, which rests in the gap of the magnet. Thus, accelerated atomic particles (protons) will not suffer collisions with gas molecules during their 3 million trips around the magnet, inside the chamber.

Chilling Methods

To cool the giant electromagnet, scientists designed a system to flow water at 500 gallons per minute through the copper windings of the magnet coils. At the heart of the system is a Patterson-Kelley water chiller capable of supplying 100 tons of refrigeration per hour—or an amount equal to that supplied by 1,200 household refrigerators.



LIQUID TEMPERATURE GAUGE at Brookhaven National Laboratory, is checked by H. E. Vanderoef, lead man, Refrigeration & Air Conditioning, on a Patterson-Kelley chiller which supplies 100 tons of refrigeration for the cooling system of a proton accelerator.

The chiller—on the water side—is made entirely of nonferrous metals to provide long-lasting service with the demineralized water. Pumps are powered by two 50-hp compressors.

Cooling begins with water which passes through the P-K Freon-refrigerant chiller at the rate of 300 gallons per minute and is circulated to the Cosmotron cooling system at an average temperature of 53 F. In order to maintain low electrical conductivity, the water is passed through a Permutition-exchange system before entering the magnet coils.

Modification of Cooler

Originally a closed system, the cooling process has been modified by two 1,000-gallon storage tanks, reducing the water to 45 F and allowing it to rise to 60 F before entering the chiller. This produced an additional 80 tons of refrigeration per hour.

Cooling water flows through coil windings of the magnet. The 48-turn windings are fabricated from 50-foot lengths of ¾-inch by 1⅞-inch copper bars, with each turn having a ⅜-inch internal cooling hole along its axis. The turns, electrically in series, are water cooled in parallel.

The Cosmotron is divided into quadrants, with each section containing 72 steel magnets. At the end of each quadrant, a copper manifold with 96 outlets connects the water system to the coil end of the conductors to form a separate cooling system for each of the four sections.

Flow meters in the water line for each

conductor are arranged to give warning signals for any flow failure, and inlet–outlet temperatures of each quadrant are measured and metered. The 2-circuit chiller further safeguards the cooling system. If one circuit becomes plugged, the other circuit remains in operation to supply cooling water.

High-Explosive Charge Forms Jet Trainer Fuel Tanks

HIGH EXPLOSIVES similar to those that blast the tops off of mountains are being used to form aircraft fuel tanks. This information was revealed recently by officials of the Columbus Division of North American Aviation, Inc. (NAA), Columbus, Ohio.

The technique is called "explosive forming" and was developed by NAA to make wing-tip fuel tanks for the *T2J* jet trainer now being built at the Columbus Division for the U.S. Navy. It was stated by officials at the Columbus plant that anyone who had ever lighted a firecracker under a tin can and had observed the resulting bulged ends of the can after the big bang had seen a basic method of explosive forming.

Varied Uses

Used industrially, it is simply a way of controlling an explosive force—a method to make that force push the metal being used against a containing die of the desired shape.

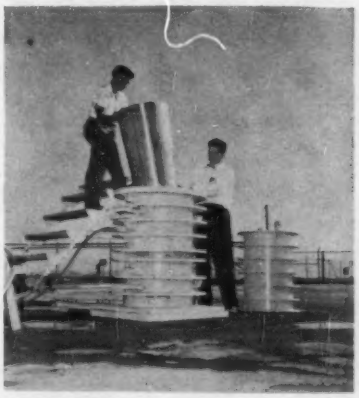
Tool engineers at the division carried out an extensive experimental and tool designing program before the adoption of explosive forming to the making of a part as large as that of the *T2J* fuel tank. Made up of two main sections, the wing-tip tank of the *T2J* jet trainer is approximately 12 feet in length and can be seen in the accompanying photograph.

Because die designs and "shooting" techniques have been developed sufficiently and successfully, production parts can now easily be made with the new system of forming.

Method of Forming

In the forming of the fuel tanks, a cone-shaped sheet of metal, about 1/16-inch thick, is placed inside the die. This cone is truncated, i.e., cut off at one end. After the cone is placed in the die, the die is filled with water. A vacuum is created between the cone and the sides of the die by pumping out the air.

The high explosive (Primacord) is then fired inside the cone. The water acts as both a force conductor and a shock dampener. The finished tank section, which has taken on the shape of the prescribed curved moldline, is then removed from the die.



TOOL ENGINEERS at Columbus Division demonstrate technique whereby fuel tanks for *T2J* jet trainer are formed by explosives. M. R. Taylor (*on ladder*) and T. B. Tedlie place cone in containing die.

Other Applications

Explosive forming is being used successfully in other applications at the Columbus Division. One use is the swaging of tubing around plug-end fixtures. This application is an example of compressive or "implosive" effect, whereby the tube is formed into the groove of the plug to which it must be attached.

Forming with explosives instead of with conventional heavy machines simplifies the production of certain aircraft components. The success by the division in making the *T2J* tip tanks has led to the planning of a production explosive forming facility.

Parts and dies would be wheeled down inclined rails into a water-filled pit. The forming charge will automatically fire when the tool and part are in position.

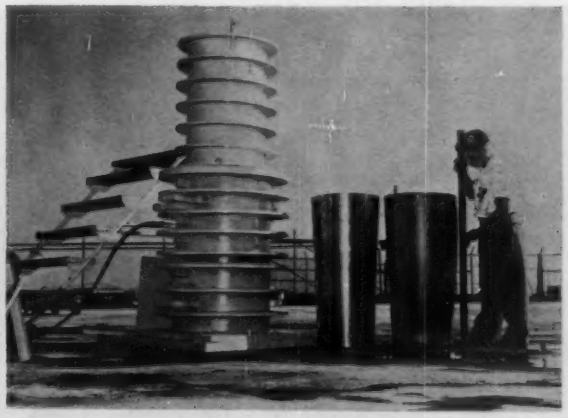
This explosive forming technique has proved highly successful, and is expected to be used for other parts manufacture as well.

Inspection Yields Cause of EBWR Blade Failure

A notch in the blade root, resulting in fatigue, was the only factor in the failure of a single blade in the turbine–generator of the Experimental Boiling Water Reactor (EBWR) at the Atomic Energy Commission's Argonne National Laboratory, Lemont, Ill.

The EBWR was shut down May 1, 1958, because of the failure. Examination

COMPLETE wing-tip tank for the *T2J* jet trainer is shown installed on the trainer which is manufactured at the Columbus Division of NAA. The explosion forming technique utilized has proved highly successful for this as well as other applications in industry.



CURVATURE of explosively formed tank section for the *T2J* jet trainer is shown by M. R. Taylor, NAA tool engineer who holds straight edge along finished part. Cone blank from which tank section is formed is in center. At left is the die in which the part is formed.

of a blade in the next to the last spindle row, at the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., disclosed that the blade and its shroud had become detached from the rotor. A row of new blades was installed and the turbine delivered full power again on June 4th.

Following extensive investigation by scientists and engineers involving metallurgical, dimensional, and vibrational studies, as well as a check of inspection reports and manufacturing procedures, a report was submitted to AEC. It disclosed that one of the fixtures used to hold the blading during machining had been incorrectly adjusted, causing a notch in the root fillet. This was a point of stress concentration, with resulting fatigue-type failure of the blade. The report also stated that there was no evidence of stress corrosion, general corrosion, intergranular attack, or other forms of surface attack. The blades were not affected in any way by steam from the reactor.

Maintenance operations were permissible inside the turbine on a routine basis almost immediately after the shutdown. Radioactivity level was only two milliroentgens per hour. (Current radiation protection standards limit exposures to 3,000 mr per 3-month period and to an average of 5,000 mr per year.)

More Phones but No Additional Cables

A MAJOR BREAKTHROUGH in telephone engineering—development of an electronic system that expands two voice channels to as many as 24 without laying any additional cable between exchanges—was announced recently at the annual convention of the United States Independent Telephone Association.

Engineers of International Telephone & Telegraph Corporation (ITT) demonstrated a new electronic "exchange carrier" system for telephone system managers, owners, and engineers attending the Association's annual gathering held in Chicago. The carrier is now being tested on actual telephone lines and will be in production the summer of 1959 in ITT's Communications Division, Kellogg Switchboard and Supply Company, they said.

"The breakthrough lies in the fact that the carrier frequency is never actually transmitted on the cable," G. T. Scharffenberger, Kellogg president, explained. "Instead, only the signal or modulation is transmitted and its frequencies constitute a sort of electronic identification tag. At the receiving end this tagged signal goes to a device called a synchronous detector which recreates the carrier called for by the tag and then sends the signal on in the proper channel."

"This exchange carrier system will enable telephone operating companies to fulfill demands for additional service in many areas more quickly and economically. It will provide additional channels between exchanges without the expense and inconvenience of excavating streets or blocking off manholes in order to install additional cables."

The new carrier system will find its greatest application in rapidly growing suburban and metropolitan areas where it will be installed to expand the capacity of exchanges located 3 to 20 miles from each other. It will also be used in smaller cities and even in semirural areas in instances where economics will dictate use of the electronic method of getting more channels for voice transmission versus the laying of cables or other additions to the "outside plant" of a telephone system, he said.

Details of Unit

Designated the *K-24* by the engineers who developed it at ITT Laboratories in Palo Alto, Calif., the new carrier system's "heart and brains" are contained in a metal cabinet that occupies a space only 32 inches high and 19 inches wide in a central office exchange. A companion cabinet is in the exchange at the other end of the system. Only other equipment required are specially developed small repeaters placed at intervals along the cable.

The *K-24* is a completely transistorized short-haul cable carrier system designed to provide voice and signaling circuits between central office exchanges. A maximum of 10 repeaters extends the range of the system to approximately 20 miles. Each installation requires two cable pairs for transmission. A 12-channel system is fully compatible with the *N1* carrier.

The system is expandable on per-channel basis up to 24 channels. Ninety-six channels are designed to mount on one side of a standard 19-inch relay rack 11 feet 6 inches high.

Frequency Allocation

The system employs double sideband suppressed carrier amplitude modulation combined with unique synchronous detection circuitry. One cable pair is used for each direction of transmission. Channel carriers are spaced on 16-kc centers from approximately 60-480 kc for each direction of transmission—with carriers in opposite directions of transmission interleaved on 8-kc centers.

Signaling panels are available on an optional plug-in basis, permitting operation with the following types of dial and supervisory circuits: (1) loop dialing with reverse battery supervision; (2) revertive pulsing, E & M signaling, and no signaling; and (3) in installations utilizing these types of interoffice dial and supervisory signals, the need for signaling applique converters is eliminated.

Compandors and Mechanics

Compandors are optional equipment. They are included in one version of the plug-in voice frequency terminating unit. This construction permits any circuit to be readily changed without additional wiring or space for optional compandors being required.

The system is designed to simplify installation and maintenance problems as much as possible. A 24-channel terminal occupies less than 31½ inches of vertical space on a standard 19-inch relay rack. "Bookshelf" construction is used in the system with seven shelves provided in each 24-channel terminal shelf.

All major circuit groups are mounted on separate plug-in boards. Printed circuit wiring is used on the boards with multi-pin connectors providing interconnection between the units.

All units mount vertically, side by side, in the shelf. One of the shelves is used for group equipment, the remainder for channels. Twelve channels require three shelves, with modems, signaling, and terminating units each using one of the three shelves. The three boards for one channel mount vertically above each other in the three shelves.

Repeaters

Both regulating and nonregulating repeaters are used on multirepeater instal-

ELECTRONIC Telephone system *K-24* creates 24 channels between phone exchanges where only two existed previously. No additional cables are needed, thus eliminating costly ripping of streets. ITT Palo Alto laboratory produces parts for the new device.

lations. Up to two nonregulating repeaters may be used between regulating repeaters, depending upon the application.

Adjustable slope equalizers and span pads are provided in each repeater section to equalize losses across the 60-480 kc band.

Power Requirements

The terminal shelf operates from a —48 d-c central office battery. Positive 130-volt plate battery may also be required depending upon the number of repeaters to be fed in tandem from a terminal. It is intended that a maximum of five repeaters may be fed from one terminal.

Channel terminal is not to exceed 5.0 watts and the repeater should not exceed 1.5 watts.

Its environmental requirements are: temperature 0 to +50 C and humidity up to 95%.

Electronics in Scientific Research

Electronic "Earmuffs." Development of an experimental electronic earphone, considered a major breakthrough in noise reduction and designed to create artificial quiet by shutting out loud noises that interfere with combat communications, was announced by the U. S. Department of the Army.

The earphones, developed by the U.S. Army Signal Corps Research and Development Laboratory, Fort Monmouth, N. J., and Radio Corporation of America (RCA) engineers in Camden, N. J., are expected to find wide use in tanks and planes, where noise is a major problem.

Scientists created the artificial quiet by adding more noise with a miniature microphone in the special earpiece to create a second noise, just as loud, but opposite in phase. When the two sound waves meet in the earcup, they use up almost all their energy fighting each other, thereby greatly reducing the noise level. As a result, a loud roar is muffled to a whisper.

The earphones, first of their kind, are expected to have many commercial as well as military uses. For instance, they could be worn by riveters and mill workers where the roar of machinery is not only a nuisance but sometimes a menace.

In combat, the earphones might be used by artillerymen to protect their eardrums and improve communications or could increase the efficiency of sonar operators by eliminating distracting noises. They might also quiet high noise levels for jet bomber and ground maintenance crews.

The earpieces work in conjunction with a special electronic inverter and amplifier unit that in large-scale production could be made small enough to fit into a soldier's pocket. The electronic system cuts low-pitched sounds down to as little as 1/10 their original volume. Higher pitched sounds are trapped by special foam cushioning.

Internal Photography. A unique internal gastro-camera for picture taking inside the human stomach has been invented and perfected by N. R. Gosselin, formerly a student at Boston University's College of Industrial Technology and now medical research engineer for the Charles Brusch Medical Center. Cambridge, Mass. The photographic device, for the first time, permits internal surface areas and cavities of the stomach to be photographed, while being viewed, in both black and white as well as in color. The miniature gastro-camera, measuring from ½ to ¾ inch long and 5/16 inch in diameter, is encased in a 2-inch long, ⅜ inch inseparable housing.

Attached to the bottom of a standard gastroscope, the camera is able to expose one to eight pictures, comparable in quality to the best photographs taken under natural or artificial light conditions. The gastroscope, a common medical instrument of metal and rubber, 28 inches long containing 40 separate optical units, is swallowed by the patient, with the camera. The patient is given a light sedative to ease muscular throat tensions, prior to the insertion, and suffers no discomfort as the camera-scope is swallowed.

The miniature camera, with fixed focal plane and its casing, consists of seven separate units with only two moving parts. There are no springs. The camera invention is founded on a moving-drum principle with an inside rotating cylinder and an outside stationary piece. A 45-degree mirror, shutter release, and film pack mechanism are encased with the rotating drum. The outside stainless-steel stationary casting, with a hole the size of a pencil head, serves as the only passage through which light is passed onto the black-and-white or color film.

Film wrapped around the inside drum, readily inserted and removed, is ⅝ inch wide and 1¼ inch long, with eight exposure areas. The interior rotating drum and light flash attachment are triggered electronically via an 0.008-inch wire running from the camera through the entire length of the gastroscope. Patients receive no electric shock. The examining physician who is able to develop black-

U. S. Army Photograph

ELECTRONIC EARPHONES create artificial quiet, enabling P2/c Leroy Fritch to hear radio messages clearly despite the roar of the tank's engines. Noise-cancelling earphones use an advanced electronic system to make one sound eliminate the other.

Future Meetings of Other Societies

ASHAE, Special Meeting, Dec 1, Conrad Hilton Hotel, Chicago, Ill. A. V. Hutchinson, ASHAE, 62 Worth St. New York 13, N. Y.

American Mining Congress, Annual Membership Meeting, Dec. 1, Plaza Hotel, New York, N. Y. J. C. Conover, AMC, Ring Bldg, Washington 6, D. C.

ASRE, 45th Semiannual Meeting, Dec 1-3, Roosevelt Hotel, New Orleans, La. E. R. Searles, ASRE. 234 Fifth Ave. New York 1, N. Y.

National Warm Air Heating & Air Conditioning Association, Annual Convention, Dec 1-4, Cleveland, Ohio.

ASME, Annual Meeting and 23rd National Power Show, Dec 1-5, Hotels Statler-Hilton, Sheraton McAlpin and New York Coliseum, New York, N. Y. L. S. Dennegar, ASME, 29 W 39 St, New York 18, N. Y.

EIA, Conference on Reliable Electrical Connections, Dec 2-4, Statler Hilton Hotel, Dallas, Texas. R. G. Roesch, 1068 S Clinton St, Syracuse 4, N. Y.

AIME, Electric Furnace Committee of Metallurgical Society, 16th Annual Conference, Dec 3-5, Hotel Statler, Detroit, Mich. H. N. Appleton, AIME, 29 W 39 St, New York 18, N. Y.

The Institute of Radio Engineers

Annual Conference, Professional Group on Vehicular Communications, Dec 4-5, Sherman Hotel, Chicago, Ill. M. J. Cudahy, 845 Chicago Ave, Evanston, Ill.

Mid-America Electronics Convention, Kansas City Section, Dec 9-11, Municipal Auditorium, Kansas City, Mo. Robert Modrcin, W. E. Fry & Co, 406 W 34 St, Kansas City 11, Mo.

Symposium, Professional Groups on Circuit Theory & Information Theory, June 16-18, 1959, U of Calif, Los Angeles, Calif. *Deadline for papers:* Dec 22. G. L. Turin, Hughes Research Labs, Culver City, Calif.

AIChE, Annual Meeting. Dec 7-10, Netherland Plaza Hotel, Cincinnati, Ohio. F. J. Van Antwerpen, AIChE. 25 W 45 St, New York 36, N. Y.

American Nuclear Society, Annual Meeting, Dec 8-10, Sheraton-Cadillac Hotel, Detroit, Mich. A. S. Griswold, ANS. 2000 Second Ave, Detroit 26, Mich.

Institute of the Aeronautical Sciences

Wright Brothers Lecture, Maurice Roy on French aeronautical research, Dec 17, Natural History Bldg, Smithsonian Institution, Washington, D. C. IAS. 2 E 64 St, New York 21, N. Y.

27th Annual Meeting, Jan. 26-29, 1959, Hotel Astor, New York. N. Y. IAS same.

American Association for the Advancement of Science, 125th Annual Meeting. Dec 26-31, Statler Hotel, Washington. D. C. AAAS, c/o Engineers Joint Council, 29 W 39 St, New York 18. N. Y.

1959

NACE, 15th Annual Conference & 1959 Corrosion Show, Mar 16-20, Sherman Hotel, Chicago, Ill. *Deadline for papers:* Jan 9. T. J. Hull, NACE. 1061 M & M Bldg, Houston 2, Texas.

Building Research Institute, Conference on Noise Control in Buildings, Jan 14-15, Hotel New Yorker, New York, N. Y. Harold Horowitz, BRI, 2101 Constitution Ave, Washington 25, D. C.

5th Annual Radar Symposium, Jan 27-29, Willow Run Laboratories, University of Michigan, Ann Arbor, Mich. Security clearance through *Secret* required. Send to: Victor Scodius, security officer, U of M, Willow Run Labs, PO Box 2008, Ann Arbor, Mich.

Overseas

National Physical Laboratory Symposium & Electronic Computer Exhibition, Dec 1-4, London, England. C. V. Wattenbach, Dictograph Telephones, Ltd., London, England.

The Institution of Telecommunication Engineers, 2nd Technical Convention, Dec 27-28, New Delhi, India. S. S. Aivar, ITE, Post Box 481. New Delhi. India

Boston University Photo Service

STOMACH CAMERA, only ¾ inch, and its 2¼-inch stainless-steel casing, is held by Brusch Medical Center nurse. Gastro-camera, first of its kind to fit inside the stomach, was invented by a former Boston University College of Industrial Technology student.

and-white or color film himself, can enlarge the original negative to 10 times its normal size without introducing further distortion.

Chromatographic Instrument. A complex apparatus, designed and built under the supervision of Dr. S. R. Lipsky, assistant professor of medicine at the Yale School of Medicine, can separate the individual components of fatty acids in the blood and tissues with greater facility than any device heretofore available. As such, it will shed new light on the composition, synthesis, breakdown, and transport of these substances in the body, and promises to be helpful in combating hardening of the arteries and other diseases.

In addition to being an extremely valuable research tool, the apparatus, which resembles a modified electronic computer, can be modified for use by the food industry to monitor the production of foods containing fats. The device provides an analysis of certain substances, particularly long-chain fatty acids, by a process known as gas–liquid chromatography. Because of its tremendous versatility, it also can be used for the detection of ultramicroscopic quantities of almost any known substance or chemical capable of being vaporized.

Its use already has led to the isolation of substances, such as odd-chain acids and highly unsaturated acids, never before thought to exist in the blood and tissues of human beings.

Two new partition agents which allow for the rapid and extensive separation of the different components of mixtures of the substances being analyzed have been developed by Dr. Lipsky. He has also designed an apparatus in which this process can take place with great rapidity and precision and which can record the amounts of the component parts of the substance under analysis.

Further detailed research may lead to new knowledge about whether the American diet contains the wrong types of foods, and even about whether the saturated fats in this diet do cause the formation of fat plaques in the blood vessels of human beings. It might also lead to new methods of processing food low in saturated fats.

The partition phases developed by Dr. Lipsky for his instrument are complex polyesters of diethyleneglycol. This material serves as a coating for the separation columns used in the device. The materials coating the columns absorb the mixtures under study, and then release the component parts of these mixtures individually so they can be measured. Some 30 substances were screened in the effort to find these partition phases.

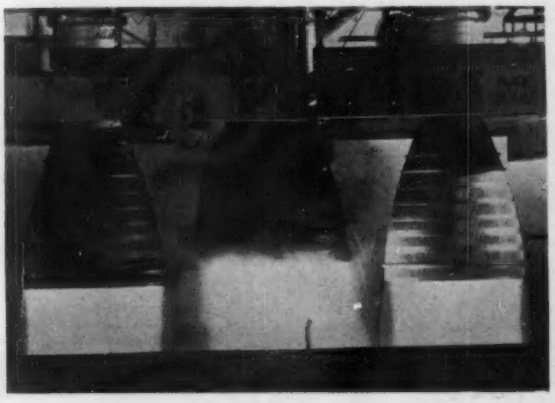
Engine Cluster Propels Atlas Missile

The powerful propulsion system for the 15,000-mph U.S. Air Force–Convair Atlas intercontinental ballistic missile (ICBM) is a cluster of liquid-propellant rocket engines. It consists of a two-chambered booster engine, a sustainer engine for high-altitude efficiency, and two small stabilizing engines. The system, designed and dveloped for the Atlas missile by Rocketdyne, a Division of North American Aviation, Inc., is in production at the main plant in Canoga Park, Calif.

Each rocket engine in the Atlas propulsion system is designed to perform a specific job. The twin-chambered booster engine provides high thrust to lift the heavy missile from its launching site. It is jettisoned after operating for its programmed duration, when it has boosted the Atlas to high speed and high altitude. The single-chambered sustainer, designed for efficient high-altitude performance, supplies the slightly lower thrust necessary to sustain powered flight and to keep the Atlas on course in the thinner air of the fringes of space. Directional stability of the missile is maintained by swiveling the large engines of the propulsion system on gimbals—a part of their assembly—and moved by struts actuated by the guidance equipment of the missile. Roll control is provided by the propulsion system's vernier or stabilizing rocket engines, small auxiliary units for precise thrust adjustments. They are mounted on the side of the missile and are also gimbaled for movement.

All engines of the Atlas propulsion system develop thrust from the propulsive gases created by the combustion of liquid oxygen and RP-1, a hydrocarbon fuel similar to that used in turbojet engines. Combustion occurs at temperatures above 5,000 F. Thrust chambers of the engines are cooled to withstand the heat by RP-1 fuel streaming through their hollow walls. The fuel is forced at high speed through the walls and into the combustion area by the engine's high-flow lightweight turbopump.

This same type of thrust system is used in the Thor missile.



CENTER CHAMBER, the sustainer engine of Atlas ICBM propulsion system, is distorted by gimbaling of engine during full-power test firing at Rocketdyne, manufacturers of system. Twin chambers on either side make up booster engine, which lifts the missile from the ground.

Amateur Astronomer Accompanied IGY Expedition

An 18-year-old amateur astronomer, David Morrison of Danville, Ill., was designated by the National Academy of Sciences' IGY Committee to accompany an expedition to the Danger Islands of the Pacific Ocean for study of a total eclipse of the sun in October.

The Executive Director of the U.S.-IGY Committee, Hugh Odishaw, said that the Academy sponsored Morrison's trip in order to stimulate wider interest in, and knowledge of, science by the young people of America. The Department of the Navy, which assisted in transporting Morrison to the Danger Islands, co-operated extensively in the eclipse expedition. An important phase of the project was the launching of research rockets from the *USS Thomaston* during the sclipse.

Morrison was nominated for the honor by the Astronomical League. He is president of its Danville Society, which has both adult and junior members. Morrison also is deputy leader of the Danville Moonwatch Team, which co-operates in the tracking of artificial earth satellites launched under the IGY program.

A June 1958 graduate of Danville High School, he was president of the Science Club there, and a finalist in the National Merit Scholarships Program. He plans to enter the University of Illinois and major in either astronomy or physics.

The path of totality for the October 12 eclipse would have begun at sunrise near the equator at about 158° E (northeast of New Guinea) and would have ended at sunset inland from Santiago, Chile. The path would have missed all the large Pacific Islands, and observations from Chile

would have been impractical because of the low altitude of the sun at the time of eclipse. The Danger Islands, the only dry land from which observations could have been profitable, in clear weather, are coral atolls too small for a large expedition. The Navy, therefore, furnished the *USS Thomaston*, which served as a floating base.

From it, the Naval Research Laboratory fired six to eight rockets equipped to detect various forms of solar radiation during the eclipse. At the same time, radio pulses were transmitted upward from one of the islands to determine height and density of the ionospheric layers of the atmosphere which reflect radio transmissions. Because these layers are ionized by solar radiation, an eclipse causes a marked decrease in their density, and the correlation of the radiation and ionospheric data collected should be especially valuable. Central Radio Propagation Laboratory, a Boulder, Colo., facility of the National Bureau of Standards, was in charge of the ionospheric radio soundings, which, like the rocket experiment, were designed to be carried on regardless of cloud cover.

Simulator Trains Nike Crews Inexpensively

A new method of training Nike missile men and other antiaircraft crews in enemy interception and destruction was disclosed recently by International Telephone & Telegraph Corporation (IT&T).

The simulated attack—duplicating actual battle conditions—was created by an electronic device (*15-D-2*) demonstrated at the IT&T Laboratories to a group of top-ranking U.S. Army officials headed by Brig. Gen. R. A. Hewitt, commanding general of the 52nd Artillery Brigade, Fort Wadsworth, N.Y.

The mobile trainer, conceived by the U.S. Naval Training Devices Center, Port Washington, N.Y., is the result of developments begun in 1956 by IT&T Laboratories.

Housed in a 20-foot trailer, it is designed to be moved from one weapons site to another. The trainer will be used at Nike guided missile centers and at 90-mm and 120-mm artillery sites both in the United States and overseas, for the continual training of fire-control and missile-guidance radar operators.

Under direction of a control officer, various combat problems are simulated with the device, exactly as they might occur in actual attack—including the first identification of an enemy plane, "jamming" of signals by the enemy, tracking of aircraft, "firing" of a missile, and "destruction" of the enemy plane.

The *15-D-2* artillery and guided missile radar signal simulator and operator trainer is primarily a training aid. Designed to operate in conjunction with either the *M-33* fire-control system or with the Nike I missile guidance system, the *15-D-2* furnishes synthetic targets when connected to an operational radar at these defense sites.

The console operator can control the simulated flight of six synthetic targets (both friendly and enemy) complete with IFF signals and electronic countermeasures interference. For each of these, he can vary its (1) east–west and north–south co-ordinates, (2) altitude, (3) climb and dive rate, (4) target heading, (5) turning rate, (6) target speed, and (7) target size.

The broad capabilities of the *15-D-2* equipment are suggested by the ranges of target functions. For example:

1. Target speed is variable between 20 to 2,000 knots.
2. Target range has a maximum of 200,000 yards.
3. Target altitudes are variable from zero to 80,000 feet.
4. The climb rate is variable from zero to 40,000 feet per minute.
5. Its dive rate is variable from zero to 80,000 feet per minute.
6. The turn rate is adjustable between zero and 20 degrees per second.

When connecting the *15-D-2* equipment, no modifications, drilled holes, or changed wiring are required on the operational radar. Connections are simple and require little time. In addition, should failure of the simulator or a defense alert occur during training operations, the radar installation can instantly be returned to a state of normal readiness.

Creation of the simulator, it is felt, eliminates the necessity of using live aircraft for training operations—an excessively costly procedure today. Furthermore, the number of operators that can be trained in this manner far exceeds that possible with live aircraft.

One of the most important safety factors in this method is the fact that at no time is it necessary actually to operate the Nike launching apparatus itself, thus eliminating any possibility of mischance in handling of the Nike missile under other training methods.

MOBILE electronic trainer is demonstrated at IT&T Nutley, N.J., laboratories. Brig. Gen. Hewitt and T. M. Douglas (vice-president of Federal Telephone and Radio Co.) look on as three USARAD school, Fort Bliss, Texas, men receive instructions on the equipment for the first time.

Film Explores Automation Techniques

A short commercial film, titled "Engineering Notebook," was recently produced to give company engineers in plants throughout the country an over-all look at progress in development of automatic manufacturing techniques at Western Electric Company, Inc., and a glimpse into the future. Western Electric is the manufacturing and supply unit of the Bell Telephone System and is also engaged in the manufacture of large electronic systems for the military agencies of the U. S. Government.

The film's central theme is that, although an engineer's solution to a single problem may not appear to be overwhelming or highly significant by itself, it is the successful merger of many ideas from many engineers that forms the basis of the company's technological progress. The engineer's notebook is used in the film as a symbol of engineering ideas.

The film first focuses on the role of the manufacturing engineer when he is presented with laboratory models. His problem is how to make highly reliable and economical units, applying techniques of automation where feasible. The basic elements of automation—programming, sensing, memory, and feedback—are noted.

The co-ordinating of manufacturing development plants is illustrated next. A typical problem is the connection of wires

PROGRAMMING a problem at 705 computer installation, Western Electric man demonstrates application of data processing techniques to company's activities.

to terminals. Basic studies indicated that more than a dozen separate mechanical movements had to be controlled in an automatic positioning machine which used a welding gun to join the terminals. A two co-ordinate base machine was developed to position the gun to within three mils and was adaptable to other work where small parts were involved.

Another group of engineers tackled the welding gun problem and developed a method for percussion welding of copper or aluminum wire to terminals. The film shows the action of the gun in slow motion. When the gun is triggered, the arc (which lasts about 400 microseconds) melts the tapered tip of the wire at a rate that delays closure. The surface of the wire tip and terminal must meet after melting and be held motionless until cool. The voltage used in the welding is a low voltage safe for personnel to use.

From these experiments a prototype general-purpose automatic surface wiring machine is being developed and is shown in the film. A paper tape programs welding in any terminal pattern, wire is prepared and fed into the gun, then carried to an intermediate position which determines the length of the wire. The wire is cut, carried to a programmed terminal, the fingers of the gun locate the terminal and make the weld.

Some of the other developments shown in the film are: a machine for attaching components to printed wiring boards, the automatic manufacture of wire spring relays, automatic assembly of transistors, and the automatic manufacture of dry reed switches. The film ends with the conclusion that there is one thing beyond the reach of machines, no matter how impressive they become: the creation of ideas.

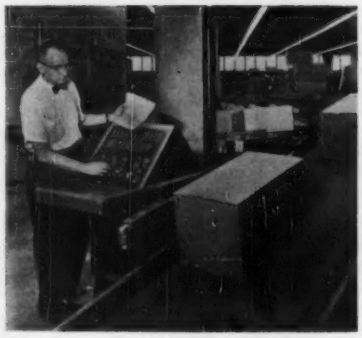
Acting on this conclusion, Western Electric offers its engineers a program of formal in-company engineering education. Designed both for new and experienced engineers, the training program is conducted at the company's expense on a full-time, off-the-job basis at various training centers throughout the country.

"Ferris Wheel" in Automated Warehouse

A five-story automated ferris wheel, controlled by an electronic memory unit, picks up merchandise at a receiving dock and distributes it to the proper floors and stations in a unique warehouse in New York City. This ferris wheel is one feature of a system of mechanical devices and automatic electronic controls that receives merchandise from over 2,000 suppliers, directs its flow through the warehouse and out to 208 stores across the country, shipping an average of 150,000 units a day, with accuracy and speed.

The new system, used in the Diana Stores warehouse, and designed and engineered by Dasol Corporation, New York, N. Y., is expected to reduce distribution costs significantly at present operating levels, and is designed to handle twice the present number of units and service twice the present number of stores.

Hanging goods and packaged merchandise arriving at the warehouse are separated at the receiving dock. The packaged goods are loaded onto a conveyor system and are dialed into the automatic control unit, which guides them to the ferris wheel which picks them up, carries them to the appropriate floor, and unloads them there onto another conveyor system which deposits them adjacent to the area where they are to be distributed. The hanging goods are handled in exactly the same manner by their own automatic control unit, which moves them by monorail to the appropriate floor and location.



RECEIVING CLERK at warehouse dials an incoming carton of packaged goods into the electronic control system. The cartons enter "ferris wheel" shown at left rear, are carried to top of building, and down other side of wheel until a mechanism combs them off conveyor at proper floor.

DISTRIBUTION CLERK removes packaged goods from cartons in which they arrived at warehouse, allocates them to each of the stores, and puts allocation in fiberboard trays on "runout table." When trays are loaded, they are placed on conveyor at left, which carries them to trayveyor system and down to second floor.

THREE-CHANNEL TRAYVEYOR SYSTEM brings trays of merchandise from distribution floors to second floor where they enter conveyor system which carries them to packing station at left. Packer unloads merchandise into shipping cartons marked for proper stores.

Meanwhile the merchandising department has decided on the destination of each item, and prepares distribution sheets directing its allocation to the stores. With the distribution sheets, IBM cards are prepared from which the bills, invoices, and labels are printed.

When the merchandising department has allocated a particular lot of packed goods, it is brought to a distribution area where fiberboard containers, each representing a store, lie on an inclined rack. The lot of merchandise is distributed into these containers, each store getting the appropriate sizes and colors. When the containers are filled, they flow by gravity on a trayveyor system which moves them down to the packing area on the second floor. The containers are there collected by stores and emptied into shipping cartons, which, in turn, pass through an automatic case sealer. From there they go to the shipping dock where they are accumulated until the appropriate carrier arrives to take them to their destination. Hanging goods are similarly handled except that the merchandise is sent down to the second floor on the return line of the same monorail system that carried them up.

The new distribution system was made possible by a reorganization of the company's procedures so that shipping to all stores is centralized in one location and by one operation. The "brains" of the system are a series of electromechanical memory units—similar in function to the memory elements in a computer—which store information about each package and each group of hanging goods, and then use that information to direct the flow in the system.

Silicon Crystals Grown without Dislocations

Dislocations, the rows of out-of-line atoms that scientists now blame for weakening metals, have been completely eliminated from crystals of silicon larger than a man's finger. In making these "perfect" crystals in unprecedented size (previously reported perfect crystals have been whiskers thinner than a human hair) scientists at the General Electric (GE) Research Laboratory have: (1) disproved a prevalent idea that dislocations "have to be there or crystals cannot grow"; (2) found important new knowledge about the causes of dislocations and how to get rid of them; (3) opened a door that may lead to making dislocation-free, and perhaps superstrong, crystals of a variety of materials in large sizes; and (4) determined that elaborate precautions will have to be taken to protect the surfaces before superstrong "perfect" crystals can be used for structural purposes: the dislocations which cause weakness apparently can be easily induced into crystals by minor surface damage.

A perfect rod of iron an inch in diameter, if it could be made, might be

as strong as a huge I-beam. However, even a small scratch made with a needle might induce dislocations that would propagate, when stressed, making the rod a hundred times weaker.

Discoverer of the new crystal-growing technique is Dr. W. C. Dash, GE physicist who described the work in Cooperstown, N. Y., at an International Conference on Crystal Growth sponsored jointly by the U. S. Air Force and the GE Research Laboratory. The secrets of Dr. Dash's techniques involve the use of specially tapered "seeds" made of high-perfection material. Tapering reduces the thermal shock experienced by the seed when it first touches the hot molten silicon from which the crystal is grown. Equally important is pulling the crystal in the proper crystallographic direction, so that dislocations are literally "left behind" as the crystal grows.

Purity of the material is important but is not a critical problem, Dr. Dash says. His largest dislocation-free crystal, which weighs about 2 ounces, is similar in purity to silicon used for manufacturing transistors and other semiconductor devices—a few impurity atoms per million silicon atoms. The strength differences between pieces of silicon with and without dislocations can be observed in a meaningful way only at temperatures of about 900 C or greater. Strength-testing of the silicon crystals is difficult because of the high temperature required and the fact that anything used to grip the sample tends to induce the strength-dissipating dislocations. Nevertheless, it has been established that those without dislocations are definitely stronger at high temperatures.

Extremely strong, whisker-size crystals of iron, copper, and many other metals have been made at the GE research laboratory and at several other laboratories throughout the world. In the case of iron, strengths up to nearly 2 million pounds per square inch have been observed, five times the tensile strength of the strongest piano wire. As a result of Dr. Dash's studies, there is the prospect of making large size perfect crystals of many substances with high strength—provided that the surfaces are protected.

The absence of dislocations in Dr. Dash's large silicon crystals has been ascertained by surface observations of a chemically etched surface; by "decoration," the method in which copper is precipitated along the dislocations inside the silicon crystal (the dislocations, or lack of them, can then be observed by "looking through" the silicon, which is transparent to infrared light); and by X-ray inspection.

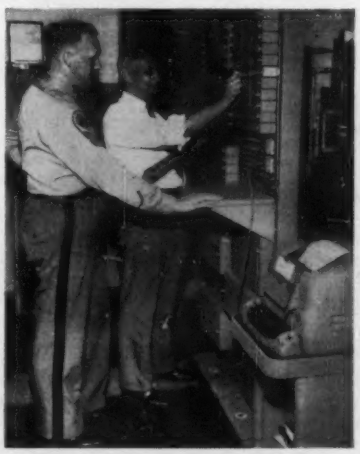
Although work is being directed toward growing dislocation-free crystals of a variety of metals, the only other material in which results have been observed similar to those in silicon is germanium, also a semiconductor from which transistors and other devices are made. The role of dislocations in determining the strength of crystalline solids has been part of new theories evolving during recent decades. It has been shown that plastic deformation of metals—bending them so they stay bent—is accomplished when dislocations permit planes of atoms to slide over each other. In the absence of dislocations, the theory suggests that metals can be bent further elastically—they return to their original shape after greater forces have been applied. The extent of such elastic deformation is a principal scientific measure of strength.

Microwave System Improves Police Efficiency

High-speed electronic communication methods have found a unique noncommercial application in the communications system of the Virginia State Police (VSP), which has pioneered in this field. Police organizations, even more than multiplant business operations, must depend on instantaneous and reliable communications in order to carry out their public service duties successfully.

The usual communications equipment used by state and other police organizations include conventional leased teleprinter circuits and two-way radiotelephone. Although the Virginia State Police makes full use of these conventional methods, the heart of its communications network is a unique microwave radio and teleprinter circuit serving exclusively the eight most active and important stations in the state: Alexandria, Appomattox, Culpeper, Norfolk, Richmond, Salem, Wytheville, and administrative headquarters outside Richmond.

The "brains" of the system is housed in a small brick building under the 400-foot microwave radio tower at the Richmond headquarters. Especially designed and built by Kleinschmidt Laboratories of Deerfield, Ill., a subsidiary of Smith-Corona Marchant, the compact, complex automatic switchboard is an electronic "genius." Operating completely automatically, it routes all calls to the proper destinations, gives a "busy" signal if a particular station is sending or receiving a teleprinted message, and clears all circuits for a general alarm or emergency message, resuming transmission of messages which were interrupted by the general alarm. Microwave radio towers, spotted about the state near the eight participating stations, relay the impulses which activate the teleprinters' keys and carry messages. It is theoretically possible for four two-way "conversations" to be going on at once on the eight-station circuit.



AUTOMATIC SWITCHBOARD of microwave radio and teleprinter circuit is inspected by Lt. J. T. Marshall, communications officer, and William Lee, radio engineer. Switchboard automatically routes calls, clears circuits for emergency messages, and resumes transmission of messages interrupted by emergency calls.

One of the main reasons why VSP installed the microwave radio and teleprinter circuit last year was because the conventional printed communications network, which in Virginia connects 53 stations on five circuits, is often overloaded, because of heavy use not only by VSP, but by the city and local police, FBI, and other state and Federal agencies. Another drawback with the leased teleprinter system is that if one station on a circuit is "talking" to another, the whole circuit is shut out, just as in the case of a party-line telephone. Lieutenant J. T. Marshall, communications officer of VSP, explained that the need was for "an exclusive network of radio and printed communications for the transmission of confidential and urgent messages affecting only the Virginia State Police. And the system had to be so designed as to be operated without additional dispatchers or other personnel."

Teleprinted messages are sent over the microwave system either manually, by typing on the teleprinter keyboard, or by tape transmission, the mechanisms of which have been adjusted for interchangeable use with the teleprinters on the conventional leased circuits. The switchboard and circuit are activated by the same microwave radio impulses used to transmit verbal messages back and forth. The microwave radio equipment, produced by Radio Corporation of America, is also housed under the Richmond headquarters radio tower. The microwave radio and teleprinter circuits are equipped with their own power, and in the event of a breakdown in telephone communications as a result of a strike, storm, or war, they would be the sole means of rapid communications in Virginia.

State police officials from all parts of the country have come to study this unique communications system which helped the VSP win numerous national awards, including one from the National Safety Council. Capable of expansion to 25 stations, the system will be enlarged as funds are made available by the Virginia State Legislature.

AIME Announces Election of Officers

At a Board of Directors meeting, the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) announced the election of officers who will be installed in February 1959.

Scheduled to take office for one year are: President, H. C. Pyle; President-elect (1960), J. L. Gillson; Vice-Presidents, T. C. Frick, W. R. Hibbard, Jr., E. A. Jones, and J. C. Kinnear, Jr. New directors, named for three years, will be: J. S. Bell,

J. C. Chipman, A. B. Cummins, C. C. Long, and J. W. Woomer. The current President, A. B. Kinzel, will continue in that post until AIME's annual convention in February.

Greater Illumination with Pastel "Floating Panels"

Luminous pastel-colored ceilings that provide up to 2½ times the illumination levels usually found in well-lighted areas are being made available for use in stores, hotels, hospitals, banks, and offices.

Produced by Silvray Lighting, Inc., Bound Brook, N. J., using General Electric Company's Power Groove lamp, the new fluorescent system is called Color-Ceil, and is designed to provide illumination of 100 to 250 foot-candles. This is done by arrangement of two-lamp units and the use of three different types of high-intensity fluorescent tubes: slimline, high output, and Power Groove. The lamps may be used individually or in combination.

The system is, in effect, a "floating panel" luminaire of extended size. The basic module, providing for four 96-inch lamps has over-all dimensions of 8 feet 2½ inches by 6 feet 3 inches. In this unit, the four lamps, each contained in its own enclosure, are spaced approximately 24 inches apart. The lamp sections are joined at their ends by an end housing which provides a mounting position for operating auxiliaries and for attachment of hangers. The spaces between the lamp enclosures are filled with sections of injection-molded plastic louver, which may be in white or in any of several pastel colors. The louver sections are supported from flanges attached to the lamp and end sections and are in convenient dimensions so that they may readily be lifted out for cleaning. Design effects are obtained in two or more colors merely by dropping in "floating" plastic eggcrate panels in desired colors between the lamp units.

Approximately one third of the light passes directly downward to the working area through the plastic egg-crate louver sections below the lamps. The balance of the light is indirectly reflected from the ceiling through larger panels of plastic louver placed between the lamp enclosure.

TRANSLUCENT drop-in plastic panels are placed in special angle brackets mounted on side of lamp's sections. Because of open egg-crate construction, panels do not accumulate dust, dirt, or grime, and are easily removable.

The system is adaptable to a considerable range of room dimensions. In larger rooms, combinations of several basic modules may be joined together to form a larger element. In very large areas, basic modules, or combinations of several basic modules, may be installed as free floating elements, spaced to suit the physical dimensions and structural limitations.

Among the features of the new system, the company notes: achievement of 82% efficiency without distortion of color value of light, and with greater shielding than previous fixture types; ease of installation and maintenance; flexibility in dimension; and concealment for ceiling beams, ducts, and pipes.

U. S.–British Comparison of Time Standards Conducted

Recent measurements of time standards made at the National Physical Laboratory of Teddington, England, show that British and American time standards differ on the average by only four parts in 10 billion, or less than one twenty thousandth part of a second in a day.

The results obtained at the National Physical Laboratory were from a comparison of British and American atomic standards of frequency or "atomic" clocks. The two standards were constructed quite independently and, although they both employ the same spectral line of the metal cesium, they differ markedly in the mechanical and electrical details and in the methods of operation.

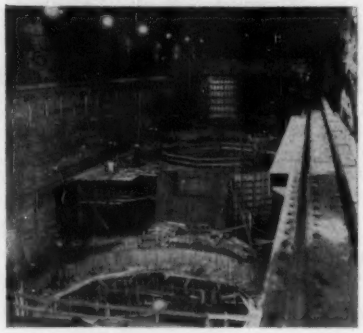
Two Atomichrons (atomic clocks) and an experimental model, made by National Company, Inc., Malden, Mass., were loaned for the purpose by the U.S. Army Signal Engineering Laboratory. All three were compared at Teddington with the National Physical Laboratory Standard. American scientists from the Signal Corps and National Company took part in the measurements.

Latest Information Available from the AEC

The U. S. Atomic Energy Commission (AEC), Washington 25, D. C., has released certain information of interest to the general public. These items are noted in the following listing.

Number	*Title*
A-211	AEC Proposes to Issue Construction Permit to Babcock & Wilcox Company for Reactor at Lynchburg, Va.
A-212	AEC Land Prototype of Triton Reactor Brought to Criticality
A-213	AEC Reactor Operates for First Time at Substantial Power with Plutonium as Fuel
A-217	Statement of the Atomic Energy Commission
A-218	AEC Proposes to License Low-Power Critical Experiments in General Electric Testing Reactor at Vallecitos Atomic Laboratory
A-220	U. S. and British Officials Meet on Atomic Information Exchange
A-221	AEC Invites Public Comment on Proposed Amendments to Its Indemnity Regulation
A-223	AEC Proposes to License New England Firms for Disposal of Radioactive Wastes at Sea
A-237	Chairman McCone to Visit AEC Plants
A-238	AEC Invites Proposals for Three Nuclear Plant Design and Engineering Studies
A-239	U.S. Presents to Geneva Conference Delegates Details of Nuclear Technology Courses for Foreign Students
A-240	AEC Statement on Proposed Piqua, Ohio, Nuclear Power Project
A-241	Fission Products Pilot Plant Begins Operations at Oak Ridge
A-242	AEC Awards 72 Contracts Totaling $3.05 Million for Physical Research
A-243	AEC Issues 18 Access Permits During August
A-244	AEC Proposes to Issue Construction Permit for Low-Power Research Reactor at Pawling, N. Y.
A-245	Chairman McCone to Attend Meeting of International Atomic Energy Agency
A-246	AEC Invites Proposals for Gas-Cooled Graphite-Moderated Nuclear Power Plant
A-247	Domestic Uranium Production Statistics for First Half of 1958 Announced by AEC
A-248	102 Life Science Research Contracts Awarded by AEC
A-250	Gas-Cooled Reactors Conference Scheduled at Oak Ridge National Laboratory
A-251	198 College, University Faculty Members Attended AEC–ASEE (American

Swedish Power Plant Operating



Sweden's largest water power station, the Ume River Stornorrfors plant, is nearing completion (*Electrical Engineering*, May 1958, p. 474). Shown in photograph is part of the rock generator hall prior to the installation of the machinery equipment. The first generating set was put into operation in September 1958; the second and third will be operating by May 1959, with a total of 375,000 kw. The discharge or tailrace tunnel, which has been blasted out of solid granite, is nearly 2½ miles long, and has a cross section of 4,200 square feet.

society for Engineering Education) Summer Institute

A-252 Uranium Enriched to 99.97% U-238 Offered for Sale by AEC

A-253 Final Engineering Design of New Hanford Reactor Assigned to General Electric Company

A-254 AEC Invites Proposals for Test Irradiation Services

A-257 AEC Issues Regulations to Guard Against Nuclear Reaction during Shipment of Fissionable Material

A-258 Uranium Isotopic Standards Now Available under AEC–NBS Co-operative Program

A-259 AEC Invites Proposals for Oxide Fuel Cycle Development for Fast Breeder Reactor

In addition to the foregoing list of interesting releases, the AEC has made available some briefs to provide American industry and science with authoritative information on important nuclear developments. These technical briefs are summaries of current developments in selected areas rather than comprehensive reviews of all published material in the field. These Nuclear Technology Briefs are as follows:

Number	*Title*
TI-7	Power Reactors, Dr. W. H. Zinn and associates, September 16, 1958
TI-8	Reactor Core Materials—Aluminum, Battelle Memorial Institute, September 18, 1958
TI-9	Joint Industry–Government Program To Develop Industrial Uses of Radioisotopes, September 29, 1958
TI-10	Reactor Core Materials—Progress in Zirconium Technology, Battelle Memorial Institute, September 25, 1958

Additional briefs will be issued by the AEC as growth and performance in the field of reactor materials may warrant. Material from these technological briefs may be reprinted in part or in entirety with proper credit to authors and institutions. Readers are urged to refer to the original works cited in any of the briefs, inasmuch as any interpretations given would represent the opinions of the compilers.

From time to time, the AEC plans to issue releases reporting technological progress in other atomic research areas, such as Spent Fuel Processing, Power Reactor Technology, etc.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Illustrations should be submitted in duplicate, one copy and inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Atomic Nucleus

To the Editor:

In the July 1958 issue of *Electrical Engineering* Current Interest section, there is an article on page 659-60 entitled "What Holds the Atomic Nucleus Together." The article is a short resume of Dr. J. J. Grebe's thesis offered before a meeting of the New York Academy of Sciences.

In his thesis, Dr. Grebe explains the nuclear forces, which hold together the fundamental particles of the atom, as high-frequency electromagnetic forces.

In my mind, I have pictured the high-frequency electromagnetic forces in the atom as a result of revolving orbital electrons, having no internal significance at all, but being only indications of the behavior of the electrons on their orbits. The negative charge of the orbital electrons and their electromagnetic fields supply the neutralization for the positive nucleus and the high speed of the electrons on their orbits distributes this neutralization more evenly around the nucleus, so that there is no external indication of any polarization in the atom.

Allow me to bring out a theory, which is a simple attempt to explain the nuclear forces with easily understood reasoning. This theory, which I worked out several years ago, falls into the category of easily understood explanations of nature's simple ways and methods.

If we prefer to work with the understanding that there exist positive and negative charges and that a force of attraction exists between a positive and a negative charge and a repelling action between two similar charges (either two positive or two negative charges), then the theory is as follows:

Theory. The simple hydrogen atom has a nucleus of one proton with a unit positive charge. Around this nucleus circulates one electron with a unit negative charge. Thus, the charge of a hydrogen atom is $+1-1=0$, as far as the external effect of the two charges are concerned. The hydrogen atom has internally a positive and a negative charge quite distinct of each other. Because of the fact that the nucleus consists of only one proton, there is no nuclear force necessary. Thus, there is only atomic force between the proton and the fast circulating orbital electron.

All other elements (including the heavier hydrogen isotopes) have more than one nucleon. The additional nucleons in heavier hydrogen atoms are neutrons and, thus, seemingly do not necessitate nuclear force between them and positively charged proton.

Experiments have shown that a neutron decays to an electron, a proton, and a neutrino (neutrino representing the binding energy between the components). Therefore, the neutron must be a combination of one proton and one electron. As the proton has a positive and the electron a negative charge, the neutron must internally be a polarized particle (or combination) having a positive and a negative pole. But, if we make the observation a short distance away, the dual charges seem to neutralize each other. In hydrogen-2 (deuterium), the neutron in the nucleus will position itself so that its negative pole (electron section) will be toward the free proton. This produces the necessary nuclear force between the two nucleons—proton and neutron.

In other elements having nuclei with more than one proton and neutron, the neutrons will position themselves so that they produce a nuclear force by keeping their negative poles toward the free protons and binding themselves together with similar arrangement.

* * *

Thus, it is not necessary to deal with any hypothetical forces, which are supposed to enter the nucleus at very short distances (distances less than the diameter of the nucleus).

The polarized neutron in the foregoing theory supplies the heretofore secret forces which hold together the fundamental particles of the nuclei. The orbital electrons, with the protons of the nuclei, supply the atomic forces which combine the atoms. The electrons, as previously stated, also neutralize the otherwise positive nuclei, so that the atom becomes externally neutral. Because of the high orbital speed of these electrons, high-frequency fields are being developed by their charges. These high-frequency fields concentrate on the nucleus, but are also observed externally at the immediate vicinity of the atom.

If the number of protons and orbital electrons in the atom is the same, the atom is neutral. If the number of orbital electrons is less than protons, the atom is positively ionized, and if it is larger, then the atom is negatively ionized.

Addenda. In the terminology of positive and negative charges, the earth is considered to be a body without charge. This is confirmed by the fact that the number of electrons and protons in the atoms is equal. Furthermore, it is estimated that the total number of neutrons in the nuclei of the elements, which are the most abundant in the formation of the earth, exceeds that of the protons by about 5%. Thus, we can divide the weight of the earth, which is about 6×10^{27} grams by the weight of the average nucleon, which is about 1.67×10^{-24} grams. Then the number of nucleons is 3.533×10^{51} from which we get 1.721×10^{51} protons and 1.812×10^{51} neutrons. The number of orbital electrons is the same as the number of protons.

The total charge of all the orbital electrons in the formation of the earth is then

$$1.721 \times -4.8 \times 10^{-10} = -8.2608 \times 10^{41} \text{ abs. electrostatic units}$$

$$1.721 \times 10^{51} \times -9.1066 \times 10^{-20} = -1.567 \times 10^{24} \text{ abs. electromagnetic units.}$$

Now, suppose that only the electrons are charged particles and the protons have no charge at all; then, there is no absolute positive charge and the earth attains a negative charge which has a value of 2.75×10^{82} coulombs absolute.

I am asking the readers to study this supposition.

Very truly yours,

E. J. MOMMO (AM '13, M '24, Member for Life)

Strato-Lab Research Aims

To the Editor:

The current Office of Naval Research (ONR) Strato-Lab program aims to make available to academic, industrial, and Government scientists a manned, sealed, balloon-borne laboratory 20 to 25 miles above the earth for purposes of research, environment testing, and systems experimentation.

If this new research tool which is being offered to scientists for their explorations is to have maximum usefulness, each prospective user must have the opportunity to participate in determining its specifications. How a research objective is to be accomplished, what particular instrumentation will be employed, what assumptions are made concerning the platform, will have to be determined for each experiment so that the functional requirements imposed on the basic Strato-Lab vehicle will become more or less evident.

Accordingly, ONR has asked Vitro Laboratories to put these questions before the scientific community:

Would a manned balloon-borne stratospheric laboratory assist or further your research and development activities?

How?

What functional requirements, i.e., stability, weight, etc., would these activities impose on the Strato-Lab?

In order to provide a forum for discussion, Vitro Laboratories, ONR, and the Institute of Aeronautical Sciences (IAS) plan to hold a joint symposium dealing with Strato-Lab applications at the end of January 1959. Papers describing possible Strato-Lab applications are invited. For further details, contact the writer.

Very truly yours,

J. J. FREEMAN
Vitro Laboratories
Silver Spring Laboratory
14000 Georgia Avenue
Silver Spring, Md.

Professional Recognition

To the Editor:

It is not often that I write a letter of protest to a publication but I am compelled to after reading the article on page 855 in the September 1958 issue of *Electrical Engineering* referring to the Mackinac Bridge.

Undoubtedly, you have read about "Professional Recognition" as it applies to engineers, yet here is an article about a bridge which begins with "Skeptics said that this was the bridge that couldn't be built . . ." and about which Postmaster General A. E. Summerfield predicted that ". . . it may very well be that future historians will include the Mackinac Bridge in the proud category of mankind's outstanding accomplishments when the story of our 20th Century is finally written, as it will be in part, in terms of our great public works," and the name of the creator of the bridge is not even mentioned.

You devote quite a number of lines to the lighting of the bridge. There are probably thousands of engineers who could have designed the lighting while there may be tens who could have designed the bridge. Yet you failed to name the engineer, Dr. David B. Steinman who designed the bridge which "couldn't be built."

How can we further "Professional Recognition" when a member of our profession does not practice it?

I believe you owe it to the profession to make a correction in the next issue of *Electrical Engineering*.

Yours truly,

H. A. DODGE (AM '20, Member for Life)

EDITOR'S NOTE: The article "Mackinac Bridge Has a Maintained Illumination of 1.0 Footcandle for Night Safety" was written to describe the lighting used on the bridge rather than the design features of the bridge itself.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

ADMINISTRATION OF SALARIES AND INTANGIBLE REWARDS FOR ENGINEERS AND SCIENTISTS. By J. W. Riegel. Publications Distribution Service, University of Michigan, Ann Arbor, Mich., 1958. 105 and 84 pages, 6 by 9¼ inches, bound. $6. These two surveys, bound in one volume, are devoted to the needs, goals, and job satisfaction of engineers and scientists. Specific aspects investigated are job activities, actions of immediate supervisors, salaries, intangible rewards, working relations with associates, company assistance to professional development, attitudes toward collective bargaining, and the administration of technical programs. The surveys are reports numbers 8 and 9 of The University of Michigan Bureau of Industrial Relations.

ANALYSIS AND CONTROL OF NONLINEAR SYSTEMS. By Y. H. Ku. Ronald Press Company, 15 E. 26th St., New York 10, N.Y., 1958. 360 pages, 6 by 9¼ inches, bound. $10. This book is intended to provide electrical and mechanical engineers, physicists, and applied mathematicians with a practical account of available techniques for dealing with nonlinear vibrations and oscillations. Both analytical and topological methods of solution are presented, electrical–mechanical analogs are explained for reciprocal solutions, systems with many degrees of freedom are discussed, and the analysis is extended to cover feedback systems with nonlinearites.

ANWENDUNG ELEKTRISCHER RECHENANLAGEN IN DER STARKSTROMTECHNIK. VDE-Verlag GmbH, Berlin, West Germany, 1958. 335 pages, 7 by 9½ inches, bound, 32 DM ($7.61). This group of 22 papers deals with the application of electric computers in high-voltage power plants. Sponsored by the German Electrotechnical Society (VDE), the three-day session at Stuttgart in November 1957 was intended to examine and assess German progress in the field. Subjects covered include the properties and efficiency of modern digital computers, comparison of analog and digital computers in high-voltage engineering work, and programming procedures.

BUILDINGS FOR RESEARCH. Published by F. W. Dodge Corporation, 119 W. 40th St., New York 18, N.Y., 1958. 224 pages, 9 by 12 inches, bound. $9.50. This book discusses the requirements of good laboratory design and provides information on such factors as safety measures, waste removal, corrosion prevention, vents and chains, and modular units. Also included are descriptions of research buildings in the fields of nucleonics, biology, electronics, and chemistry. A special section deals with atomic processes and equipment as they affect the design of the laboratory. The volume comprises a collection of articles published in *Architectural Record* since 1950.

CALCULUS FOR ELECTRONICS. By A. E. Richmond. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 407 pages, 6 by 9¼ inches, bound. $6. Presenting simultaneously the processes of calculus and their application to problems in electrical and electronic circuits, the book begins with the fundamental concepts of calculus, and develops the basic operations of differential and integral calculus. It continues with special topics such as the complex exponential representation of a physical sinusoid, Taylor's expansions of functions of two independent variables, Fourier's series, and an introduction to differential equations.

CONFORMAL TRANSFORMATIONS IN ELECTRICAL ENGINEERING. By W. J. Gibbs. Chapman and Hall, Ltd., London, England, 1958. 219 pages, 5½ by 8¼ inches, bound. 45s. ($6.30). Preliminary material on the elements of field theory and of complex numbers is followed by transformations in the order of increasing complexity. The second half of the book deals with transformations involving elliptic functions. Emphasis is placed on the application of transformations to engineering problems.

CONTROL SYSTEM COMPONENTS. By J. E. Gibson and F. B. Tuteur. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y. 1958. 493 pages, 6¼ by 9¼ inches, bound. $12. An analytic treatment of the most commonly used components in servomechanisms and other feedback control systems, is presented. The approach is theoretical in nature and includes recent advances in magnetic amplifiers, transistors, and hydraulic and pneumatic systems. Much of the material covered, such as the sections on network synthesis, thyratron amplifiers, a complete system analysis of valve-operated hydraulic systems, and relay amplifiers, has appeared only in periodical literature.

DIGITAL TECHNIQUES FOR COMPUTATION AND CONTROL. By M. L. Klein and others. Instruments Publishing Company, Inc., 845 Ridge Ave., Pittsburgh 12, Pa., 1958. 394 pages, 5¾ by 8½ inches, bound. $6. This survey of the basic techniques used for digital computation and control includes code arithmetic, logical networks, multiplexing, conversion, data reduction, digital process control, two-terminal relay circuits, counting techniques, digital computers of all types, computer programming, digital differential analyzers, and combined analog–digital equipments. Descriptions of components and available commercial equipments add to the value of the book.

THE EARTH AND ITS GRAVITY FIELD. By W. A. Heiskanen and F. A. Vening Meinesz. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 470 pages, 6 by 9¼ inches, bound. $12.50. Although primarily concerned with the earth's gravity

field, this volume also deals with mathematical and astronomical geodesy as well as the inner constitution of the earth as indicated by seismology and geomagnetism. Advances studied are the global significance of the pendulum apparatus of Vening Meinesz for gravity observations at sea, the invention of the gravimeter, and the tying of the gravity base stations of the world to the world gravimetric system.

ELECTRIC MACHINERY. By C. C. Carr. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 537 pages, 6 by 9¼ inches, bound. $9.25. A co-ordinated presentation covering transformers as well as both direct and alternating machines, this book covers types of windings, voltage relations, magnetic-field relations, energy losses, energy flow, efficiency, ratings, and basic torque relations. These principles are then applied to a detailed analysis of the performance of different types of machines

ELECTRONIC CIRCUITS. By E. J. Angelo, Jr. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 450 pages 6¼ by 9¼ inches, bound. $9. The first half of the book is concerned with the development of linear and piecewise-linear circuit characterizations for tubes and transistors, and with the behavior of these devices in basic amplifier configurations. The second half treats linear tube and transistor circuits, and presents an introduction to active circuit theory. Among the concepts and techniques developed are the controlled source, logarithmic amplitude and phase characteristics, and the pole-zero patterns for voltage and current transfer ratios.

ENGINEERING ELECTROMAGNETICS. By W. H. Hayt, Jr. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 328 pages, 6 by 9¼ inches, bound. $8.50. The primary objective of this volume is the development and understanding of Maxwell's equations. The material discussed includes electrostatics, the steady magnetic field, time varying fields, as well as numerous examples illustrating the applications of Maxwell's equations. The final chapters provide an introduction to skin effects, wave motion, circuit concepts, radiation, relativistic effects, and relaxation and iteration methods of experimental mapping.

GMELINS HANDBUCH DER ANORGANISCHEN CHEMIE. Eighth edition. Verlag Chemie, Weinheim/Bergstrasse, West Germany, 1958. System Nr. 45, Germanium, Ergänzungsband. 576 pages, 7 by 10 inches, paper. $79.68. The 576 pages of the current supplement notably represent the rise in importance of germanium when contrasted with the 62 pages of the 1931 volume. The compounds and alloys of germanium, its technical preparation, and its properties—particularly the optical, electric, and photoelectric—are covered in detail, with over 400 pages devoted to the physics of germanium emphasizing the technical significance as related to semiconductor phenomena, transistors, and phototransistors. Parallel columns of English and German tables of contents assist in the use of this extensive compilation of technical data and references.

INDUCTION MOTORS: SINGLE-PHASE AND POLYPHASE. By C. S. Siskind. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 390 pages, 6¼ by 9¼ inches, bound. $7.50. Discussing the principles, standards of operation, applications, control, and design of single-phase and polyphase induction motors, the book gives considerable attention to the winding and to motor control. Such recent developments as new braking methods and speed-control procedures involving special winding arrangements are presented.

INFORMATION AND COMMUNICATION PRACTICE IN INDUSTRY. Edited by T. E. R. Singer. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y., 1958. 304 pages, 6 by 9¼ inches, bound $8.75. Intended as a comprehensive view of the subject, this volume considers technical writing, editing, and illustrating; classification; information services and their part in internal communications; operations research; patent collections; research files; punched cards; training the literature scientist; translating; and indexing and abstracting.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint of a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 20 W 39 St., New York 18, N. Y.

INTRODUCTION TO ELECTROMAGNETIC FIELDS. By Samuel Seely. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 308 pages, 6 by 9¼ inches, bound. $8.50. An introduction to Maxwell's equations and electromagnetic field theory, the volume begins with consideration of the current flow field and continues with the static electric field, the static magnetic field, and dynamic fields. Emphasis is placed on the concept of energy storage in fields and on the energy flow concept.

LEITFADEN ZUR BERECHNUNG VON SCHALLVORGÄNGEN. By O. Brosze. Second edition. Springer-Verlag, Berlin, West Germany, 1958. 168 pages, 6¼ by 9¼ inches, bound. 31.50 DM ($7.50). A manual for the calculation of acoustical phenomena, the book is divided into three main sections: the sound radiation field at a great distance from the emitter, the field close to the emitter, and the fields of spherical emitters. The purpose is to develop the basic formulas and concepts and to apply them to typical examples.

MAGNETIC RECORDING TECHNIQUES. By W. E. Stewart. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 272 pages, 6¼ by 9¼ inches, bound. $8.50. Principles of the recording and reproducing process, recording materials, the theory of ferromagnetism, recording mechanisms, and established standards are discussed. Design techniques are given for the various elements of the magnetic recording system. New fields of application covered include boundary recording in computer memory work, the Factrol system used in automation, flux-sensitive heads, and television recording problems.

MATHEMATICS OF PHYSICS AND MODERN ENGINEERING. By I. S. Sokolnikoff and R. M. Redheffer. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 810 pages, 6 by 9¼ inches, bound. $9.50. This text attempts to strike a balance between the logic of mathematics and its applications. A wide variety of topics are treated such as the use of complex forms of solutions for linear differential equations; mean and point-wise convergence of Fourier series; a modern treatment of probability and relative frequency; Dirac's function in connection with the Laplace transform; matrices, vector spaces, and field theory; and the relation between differential and difference equations.

NETWORK SYNTHESIS. By Norman Balabanian. Prentice Hall, Inc., Englewood Cliffs, N. J., 1958. 433 pages, 6 by 9¼ inches, bound. $12. The author discusses one-port realizations, including networks with two kinds of elements and general RLC networks; and transfer function synthesis, including lossless two-ports, RC two-ports, and general RLC two-ports. Special features are the presentation of the Bott–Duffin and Dasher methods as well as a complete description of Ozaki's work.

NUCLEAR REACTOR METALLURGY. By W. D. Wilkinson and W. F. Murphy. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1958. 382 pages, 6 by 9¼ inches, bound. $5.60. Preliminary material on general metallurgy is followed by a discussion of the problems presented by specific metals, including uranium, plutonium, thorium, beryllium, and zirconium. Specialized areas discussed include metallic materials with large cross sections for thermal neutrons, liquid metals, the use of ceramics in nuclear technology, and the effects of neutron radiation on nonfissionable metals and alloys.

NUCLEAR ROCKET PROPULSION. By R. W. Bussard and R. D. DeLauer. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 370 pages, 6¼ by 9½ inches, bound. $10. Various aspects of the subject are discussed including heat transfer, structural analysis, fluid flow, thermodynamics, ballistic flight, reactor physics, and radiation safety. Many sections of the volume have applicability to all types of high-power density fission reactor design including mobile and ground power reactors. A feature of the book is the detailed explanation, with examples, of the presently used methods of systems analysis.

PRINCIPLES AND APPLICATIONS OF RANDOM NOISE THEORY. By J. S. Bendat. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 431 pages, 6 by 9¼ inches, bound. $11. The author indicates how to formulate difficult noise problems, derive their solutions, and obtain proper physical design and interpretations. The book discusses probability theory, random noise analysis, random processes, engineering systems, correlation functions, power spectral density functions, and optimum filters.

REACTORS OF THE WORLD. Published by Simmons-Boardman Publishing Corporation, 30 Church St., New York 7, N.Y., 1958. 12 folded plates, 9 by 12½ inches, paper. $2.50. Cutaway drawings with data on operating conditions are provided for 12 nuclear reactors located in Canada, Great Britain, the U.S.S.R., and the United States. The drawings were originally published in issues of *Nuclear Engineering*, London, England.

THE REPRODUCTION OF COLOUR. By R. W. G. Hunt. Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1958. 208 pages, 6¾ by 8¾ inches, bound. $12.75. The first portion of the book deals with basic principles: trichromatic color reproduction, additive and subtractive principles, color triangle, and color standards and calculations. The second part deals with specific applications such as three- and four-color half-tone printing and the transmission of color television.

THE SOCIAL HISTORY OF LIGHTING. By W. T. O'Dea. The Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1958. 254 pages, 6¼ by 10 inches, bound. $8.50. A detailed history of lighting from its earliest use to the present, the book considers lighting from the standpoint of the home, travel, work, worship, superstition, theater, outdoor festivals, lighthouses, and the materials used in producing light. The author is with the Science Museum, London, England.

SUCCESSFUL PROCESS PLANT PRACTICES. By R. L. Davidson. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 302 pages, 6 by 9¼ inches, bound. $10. Practical methods and devices to solve different problems relating to managing, scheduling, operating, maintaining, and repairing in the process industries are presented. Pumps, towers, reactors, piping, valves, motors, instruments, exchangers, condensers, machine shops, and insulation are given treatment, and working data is provided such as dimensions, operating conditions, materials of construction, and the tools to be used.

SWITCHING CIRCUITS WITH COMPUTER APPLICATIONS. By W. S. Humphrey, Jr., McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 264 pages, 6 by 9¼ inches, bound. $8.50. The text starts with a treatment of Boolean algebra and then applies this algebra to the design of some relay networks. Codes and related topics are discussed as a basis for problems in later chapters. Boolean matrices, bilateral networks, cascaded networks, and sequential circuits are discussed. Emphasis is placed throughout on reduction in complexity as a means of improving reliability as well as reducing cost.

TECHNOLOGY OF COLUMBIUM (NIOBIUM). Edited by B. W. Gonser and E. M. Sherwood. John Wiley and Sons, Inc., 440

Fourth Ave., New York 16, N.Y., 1958. 120 pages, 8½ by 11¼ inches, bound. $7. Summarizing the present status of knowledge concerning columbium, the seventeen papers included study this metal from the standpoint of economic and supply aspects, properties, extractive and physical metallurgy, analytical problems, and various specialized aspects. The papers were presented at a symposium sponsored by the Electrochemical Society, May 1958.

VACUUM-TUBE AND SEMICONDUCTOR ELECTRONICS. By Jacob Millman. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 644 pages, 6¼ by 9¼ inches, bound. $10. An integrated treatment of vacuum tubes and transistors, the volume begins with the motion of charged particles in a vacuum and with the electronic theory of a metal, and continues with the nature of semiconductors. An analysis of the vacuum diode is followed by the p-n junction, and vacuum triode characteristics and their equivalent circuits are followed by a corresponding treatment of transistor characteristics and equivalent circuits. Methods of analysis and characteristics common to many different devices and circuits are emphasized. The book concludes with various circuit applications.

WATER POWER ENGINEERING. By Rolt Hammond. Heywood & Co., Ltd., London, England; distributed by Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1958. 302 pages, 5¾ by 8¾ inches, bound. $10. The book begins with a survey of the water power industry and such aspects as planning, underground power stations, geological factors, and the relationship between water and nuclear power. The main types of turbines are then studied with stress on full scale and model tests and on cavitation. Such electrical problems as insulation, high-voltage transmission, voltage regulation, and cables are also considered.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

RESEARCH ON POWER FROM FUSION AND OTHER MAJOR ACTIVITIES IN THE ATOMIC ENERGY PROGRAMS, January–June 1958. This six-month report, divided into two sections—major activities in the atomic energy programs and progress toward producing power from controlled fusion—includes material on military applications, international activities, physical research, biology and medicine, and community activities. Appendixes, presenting pertinent reports and listings, are included. Prepared by the U.S. Atomic Energy Commission, the booklet is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. at $1.25.

STANDARDS. The American Standards Association (ASA) has made available two new international standards for electric equipment for railroads: *IEC Publication 101*, Rules for Auxiliary Machines on Motor Vehicles; and *IEC Publication 102*, Rules for Electric Transmission of Vehicles with Diesel Engines, both published by the International Electrotechnical Commission. The publications may be ordered from ASA, PR Dept. 15, 70 E. 45th St., at $2.40 for No. 101 and $3 for No. 102. Also approved by the ASA and published by ASME is American Standard *Y32.10-1958*, Graphic Symbols for Fluid Power Diagrams, a national standard for graphical symbols to be used on hydraulic and pneumatic circuit diagrams for fluid power systems. It shows basic symbols, describes the principles on which these symbols are based, and illustrates some representative composite results. Copies of this new standard are available at $1.50 from either ASA or ASME, 29 W. 39th St., New York 18, N.Y.

INSULATION TESTING BY D-C METHODS. By E. B. Curdts, director of engineering, James G. Biddle Co., the booklet is divided into five chapters: historical review, basic principles, interpretation of tests by the step-voltage method, types of apparatus which may be tested by the step-voltage method, and test equipment requirements. Three appendixes—d-c dielectric test set selection chart, bibliography, and the recognition of possible measurement errors in d-c dielectric testing in the field—are included. Copies, at $2 each, may be obtained from the James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.

ELECTRODEPOSITED METALLIC COATINGS. This compilation of American Society for Testing Materials (ASTM) Standards, superseding the 1955 issue, covers such materials as electrodeposited zinc, cadmium, nickel, chromium, and lead for steel. Coatings for copper, copper-base alloys, zinc and zinc-base alloys are also covered. Recommended practices for preparing metals for plating are included. The book contains seven specifications, three methods of test, and nine recommended practices. Of the total 19 standards, five are new, recently revised, or have had their status changed within the year. Copies of this book may be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at $2.25 a copy.

STEAM TURBINE PERFORMANCE AND ECONOMICS. By R. L. Bartlett, Large Steam Turbine-Generator Department, General Electric Company, this is a combined guidebook and reference for the power industry on the subject of calculating steam power plant performance and its application in preparing economic studies. There is extensive information on important recent developments in the field, performance of single reheat cycles, double reheat cycles, and combined cycles, and supercritical pressure and temperatures above those in use. Consideration of equipment costs, the cost of steam power plants, and operating and investment costs is included. Further details on the book are available through McGraw-Hill's Book Information Service, 327 W. 41st St., New York 36, N.Y. $12.50.

APPLICATION OF ATOMIC ENGINES IN AVIATION. Written by G. N. Nesterenko, A. I. Sobolev, and Yu. N. Sushkov, and first published in 1957 by the Military Press of the USSR Ministry of Defense, this book was translated by the Technical Documents Liaison Office, Wright-Patterson Air Force Base. The 180-page book was written by Soviet nuclear and rocket experts and considers the prospects for the use of atomic energy in aviation and its advantages, including the vast increase in flight range and the conservation of world petroleum reserves. General design, specifications, and types of airborne nuclear reactors are also examined. Diagrams of possible aircraft atomic power plants are illustrated and discussed. Chapters are devoted to atom-powered aircraft, the use of atom engines for interplanetary flight, and advantages of nuclear fuels for space flight. Projected atomic space rockets are discussed, and a program is proposed for attaining cosmic speeds. The illustrated book, *PB 131908T*, may be ordered from Office of Technical Services, U.S. Department of Commerce, Washington 25, D. C., at $3 a copy.

EDISON ELECTRIC INSTITUTE. Three publications have been made available by the Edison Electric Institute (EEI): Guide for Specifications for Revenue Metering Facilities Installed in Metalclad Switchgear, Publication No. 58-5, a joint report of the Meter and Service Committees of the Association of Edison Illuminating Companies and EEI, 1958, 25¢; Specifications for Porcelain Wireholders, TD-24 1957, approved by Transmission and Distribution Committee of EEI and one of a series to be issued by this committee covering various materials used in line construction; and EEI-NEMA Standards for Multiple Sockets and Supports Used in Street and Highway Lighting, EEI Pub. No. TDJ-147, NEMA Pub. No. SH 17-1958, report of the Joint Committee of EEI and NEMA on Standardization of Street Lighting Equipment. All three publications are available from EEI, 420 Lexington Ave., New York, N.Y.

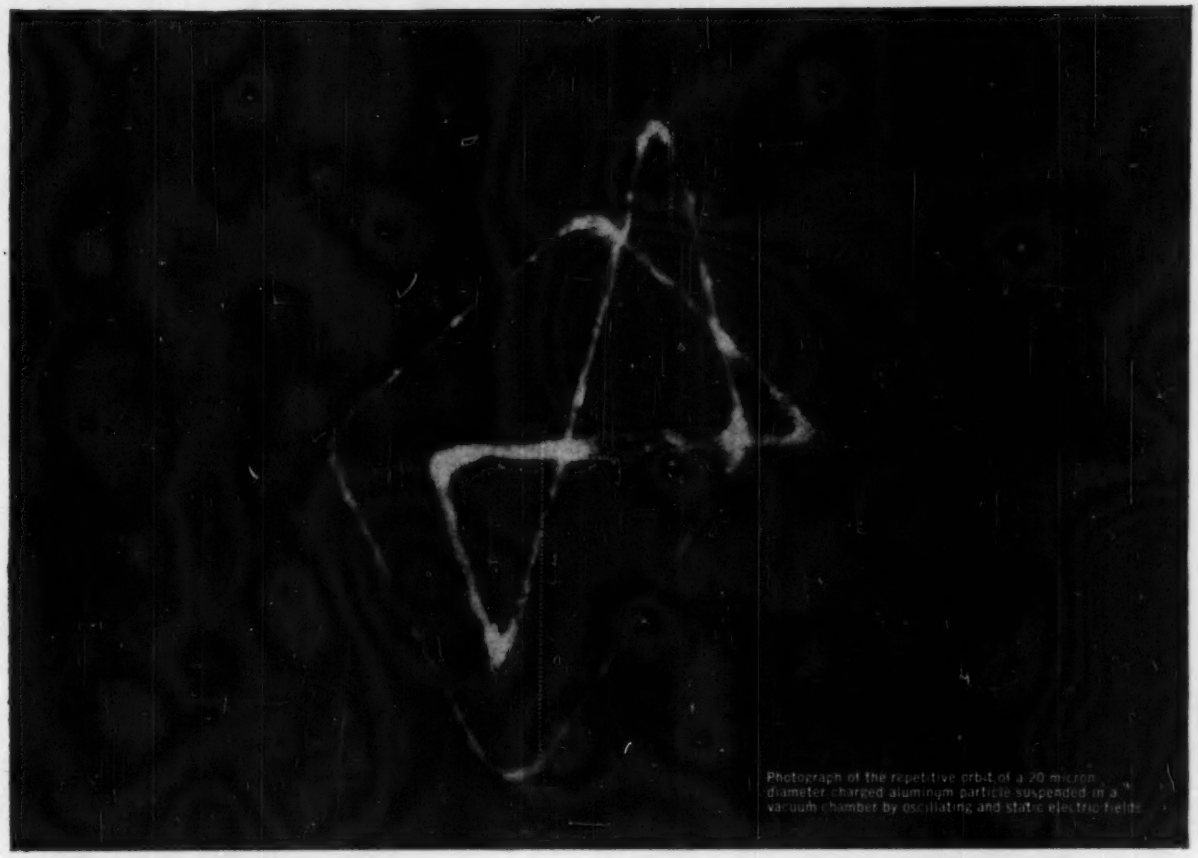
PROCEEDINGS OF THE SRE–OMRE FORUM, 1958. The forum was held in Los Angeles in February 1958 for the Atomic Energy Commission, to assist industrial, municipal, and other groups to keep informed on the status of the civilian nuclear power program. Administered by Atomics International, a Division of North American Aviation, Inc., the forum included the latest information on the Sodium Reactor Experiment (SRE) and the Organic Moderated Reactor Experiment (OMRE). This report includes the papers presented at this forum, together with reproductions of the slides shown during the two sessions. Each group of slides is numbered separately and is included at the end of the contributing author's paper. Included also is a record of the discussion periods following each of the two sessions. The report is available from the Office of Technical Services, Department of Commerce, Washington 25, D. C., at $3.

HANDBOOK OF AUTOMATION, COMPUTATION, AND CONTROL. Volume I: Control Fundamentals. Written and edited with system engineering emphasis in mind, the three-volume handbook covers material of direct use to all levels of technical personnel, in all areas of control, including management with some technical background. The major objective is to provide practical data for research, development, and design in the fields of feedback control, computers, data processing, control components, and control systems. Volume I, Control Fundamentals, includes sections on general mathematics, operations research and numerical analysis for digital computation, feedback control, information theory, smoothing, filtering, and data transmission. The 1,020-page volume is now available at $17 from John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y. Volume II, Computers and Data Processing, and Volume III, Systems and Components, will be available in 1959. The handbook was prepared by a staff of specialists and edited by E. M. Grabbe, Simon Ramo, and D. E. Wooldridge, of the Ramo-Wooldridge Corporation.

STATIC CONTROL APPLICATION MANUAL. This 152-page illustrated publication discusses what static control is and tells why, when, and where it should be used for general purpose industrial applications. Sections of the manual cover the logic concept; fundamental electrical and mechanical descriptions of static control; operation of general purpose control components; circuit design; panel layout including device arrangement, outlines, drilling plans, and complete wiring diagrams; and system check-out procedures on test, troubleshooting, repair, and replacement. A glossary lists all appropriate technical terms. The manual is available for $3 from General Purpose Control Department, General Electric Company, Schenectady 5, N.Y.

AIIE ABSTRACTS. The American Institute of Industrial Engineers (AIIE) has published its first series of abstracts of research performed in the field of industrial engineering. The ultimate objective of the Research Information Committee, AIIE, is to obtain a complete compilation of all completed industrial engineering research work. A second survey concerning research completed between July 1947 and July 1952 is about to begin. The committee would appreciate receiving research abstracts of work performed during this period. Organizations which did not fully complete the listing of their research for the period July 1952 to July 1957 should include abstracts of this information in the second survey. Information submitted or requests for information should be sent to Research Information Committee, AIIE, Department of Industrial Engineering, Washington University, St. Louis 5, Mo.

REPORT ON PROFESSIONAL INCOME OF ENGINEERS, 1958 Survey. Based on a survey conducted by the Engineering Manpower Commission of Engineers Joint Council (EJC), this comprehensive report on salaries of engineers contains data broken down into some 20 industrial activities, various levels of government, and engineering education. Special tables present separate data for engineers with master and doctorate degrees. Advance orders through EJC, 29 W. 39th St., New York 18, N. Y. Price $3.



Photograph of the repetitive orbit of a 20 micron diameter charged aluminum particle suspended in a vacuum chamber by oscillating and static electric fields

ELECTRODYNAMIC ORBITS

By the application of properly chosen alternating and static electric fields, electrically charged particles can be maintained in dynamic equilibrium in a vacuum against interparticle and gravitational forces. This is illustrated in the above photograph of the orbit of a charged dust particle. During the time of exposure the particle traversed the closed orbit several times, yet it retraced its complicated path so accurately that its various passages can barely be distinguished.

The range of particles of different charge-to-mass ratios which can be contained in this manner is determined by the gradients of the static and alternating electric field intensities and by the frequencies of the latter. In the absence of static fields and for a given electric field strength, the minimum frequency required for stable containment of the particles is proportional to the square root of their charge-to-mass ratios. Thus, charged colloidal particles require the use of audio frequencies, atomic ions need HF frequencies, while electrons require the use of VHF and higher frequencies.

Under the confining influence of the external fields, the particles are forced to vibrate with a lower frequency of motion which is determined by the external field intensities, space charge, and the driving frequencies. If the initial thermal energy is removed, a number of particles may be suspended in space in the form of a crystalline array which reflects the symmetry properties of the external electrodes. These "space crystals" can be repeatedly "melted" and re-formed by increasing and decreasing the effective electrical binding force. These techniques offer a new approach in the study of plasma problems and mass spectroscopy in what may be properly termed "Electrohydrodynamics."

At The Ramo-Wooldridge Corporation, work is in progress in this and other new and interesting fields. Scientists and engineers are invited to explore current openings in Electronic Reconnaissance and Countermeasures; Microwave Techniques; Infrared; Analog and Digital Computers; Air Navigation and Traffic Control; Antisubmarine Warfare; Electronic Language Translation; Radio and Wireline Communication, and Basic Electronic Research.

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New and Improved Products . . .

Sky-Hi-Lift . . .

The Sky-Hi-Lift was developed for fork lift trucks. One electric fork lift truck equipped with the Sky-Hi-Lift becomes a dual purpose machine that can be used for high stacking and unstacking as well as for the loading and unloading of merchandise in over-the-road trailers, operations which formerly required two separate fork trucks. The Sky-Hi-Lift is offered with a collapsed height of 68 inches that can lift to 144 inches. The low 68-inch mast has been especially designed for trucks with 2,000- and 3,000-pound capacities since the vast majority of trailer-truck beds have difficulty supporting lift trucks of greater capacity. Additional information about the Sky-Hi-Lift may be obtained from **Automatic Transportation Company, 101 W. 87th St., Chicago 20, Ill.**

Automatic Wire Cutter and Stripper . . .

The Acme wire cutter and stripper is completely automatic from unreeling of insulated wire, through simultaneous cutting and stripping, to stacking pieces in a trough. Designed for high production operations, the Acme machine does over 9,000 pieces per hour for 1- to 40-inch wire lengths. On longer lengths, rates graduate down to some 3,000 pieces per hour for 80- to 120-inch lengths. **Jennings Machine Corporation, 3452 Ludlow St., Philadelphia 4, Pa.**

Portable Welding Gun . . .

Press the tip of this new portable welding gun against a thermocouple wire, push a button, and, CLICK, the wire is welded in place. Made especially for rapid spotwelding of thermocouple junctions and similar light assemblies, the welder consists of a welding gun, connected by cable to a transformer and holster suspended from the operator's shoulder. A longer cable, 200 feet, connects this portable equipment to a control console which contains the two-channel weld sequence circuit and a pneumatic system for controlling the weld and forge pressures applied by the gun. In contrast to conventional condenser-discharge welders, the model *4032* employs ignitron power control circuits for precise control of weld current. **Research, Incorporated, 115 N. Buchanan, Hopkins, Minn.**

Two-Channel Medical Scope . . .

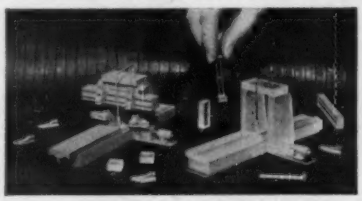
Engineered specifically for medicine, the new Levinthal Duo-Trace Cardioscope simultaneously displays two independent physiological signals. A typical application of the new instrument is simultaneous observation of electrocardiograph and electroencephalograph signals for monitoring anoxia in surgery. However, other applications include recovery-room and cardiac-ward monitoring, cardiac catheterization, and phonocardiography. For permanent recording of signals, the Duo-Trace Cardioscope provides an output jack for each channel to which standard electrocardiograph or other recording equipment may be attached. **Levinthal Electronic Products, Inc., Stanford Industrial Park, Palo Alto, Calif.**

Electronic Glass Tester . . .

A constant-voltage electronic tester, called Pfaudlertron, designed for nondestructive testing of surface continuity in glassed-steel equipment, has been introduced. The tester is the first completely electronic precision instrument specifically engineered for field testing glassed-steel equipment. It has already been accepted as an industry standard. The new unit has a stabilized output of 3,500 volts a-c, and will indicate contact with as much as ⅛ inch gap between probe point and metal. The complete unit consists of a self-contained control cabinet with direct reading meter on case, and recessed back for convenient storing of handle, probes, and leads, a 25-foot probe cord, a lucite handle containing neon indicator light, and both brush and pointed probes. Further information on the Pfaudlertron may be obtained by writing: Advertising Manager, **The Pfaudler Co., 1068 West Ave., Rochester, N. Y.**

Three-Dimensional Plant Layout Kit . . .

A do-it-yourself plant layout kit can provide three-dimensional plans that are much more effective than two-dimensional templates. These kits include planing mills, lathes, milling machines, drilling and sawing machines, sheet metal machines, office equipment, etc., all scaled



to size for effective plant layout. In addition thousands of extra parts such as pipe, fittings, motors, etc. are available with which to solve plant layout problems. **Scott Industries Inc., Olean, N. Y.**

Ground Level, Tamper-Proof Distribution Transformer . . .

Designed especially for use with residential and commercial underground distribution systems, this compact unit provides an economical solution to transformer installations for underground distribution systems. The unit is completely self-contained and is designed to be mounted on a concrete pad above ground level. No protective enclosure is required for installation. All live parts are enclosed in a locked compartment, and a welded-on cover is used. Access to the bushings, fuses, and disconnects is gained through a hinged door to the operating compartment. **Rural Transformer & Equipment Corporation, 1902 E. North, Waukesha, Wis.**

Mechanical Storage System . . .

At the touch of a selective electrical control, this device picks up the load to be stored, transports it horizontally and vertically to any desired area in the storage wall, then rolls it gently into a protected and dust-free drawer or compartment. Retrieving of the load in the exact condition in which it was delivered to storage, and transportation to work areas

or shipping platform is accomplished with the same automatic ease. Because the retriever permits use of plant or warehouse space right up to the roof, it can provide up to four times more cubic feet of storage per square foot of aisle and rack area than conventional methods, often eliminating the need for costly plant additions. **Triax Equipment, 3921 Mayfield Rd., Cleveland 21, Ohio.**

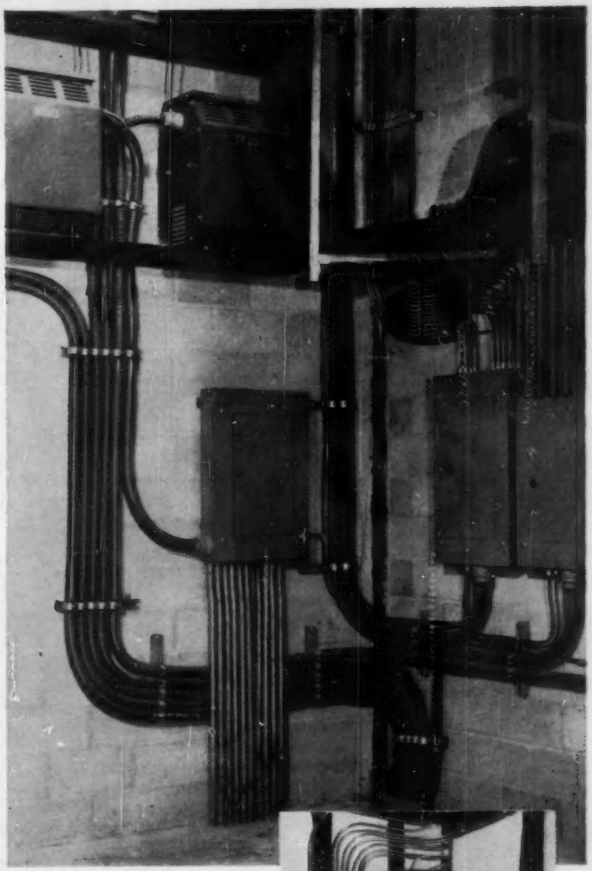
5-Digit D-C Voltmeter . . .

Model *DVA-501* automatically measures d-c voltages and prints the results on paper tape. The instrument features totally transistorized circuits and will measure d-c voltages between 0.001 to 999.99 volts to an accuracy of ±0.01% (and one digit). Ranging and polarity are automatic. Average balance time is two seconds. **Electro Instruments, Inc., 3540 Aero Ct., San Diego 11, Calif.**

(Continued on page 24A)

the right combination for industrial power needs!

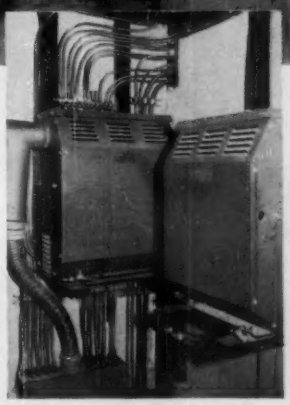
Only General Cable manufactures both...



Installation at the St. Regis Paper Company, Jacksonville, Fla. plant.

TYPE M.I. CABLE

for distribution, control and lighting circuits



INTERLOCKING ARMORED CABLE

for primary power feeder circuits

Easy to install in all locations, both Safety M I Cable and Interlocking Armored Cable require no mechanical protection, thus lowering costs of installation and minimizing space requirements. These constructions are easy to train around equipment or structural members, assuring the absolute minimum of interference, and present a neat, functional appearance. In addition, Safety M I Cable has unequalled physical and electrical properties: it is completely resistant to moisture, aging, nearly all chemicals, and operates at continuous high temperatures. For truly modern wiring in your plant, specify Safety M I Cable and Interlocking Armored Cable. And remember; only General Cable makes them both.

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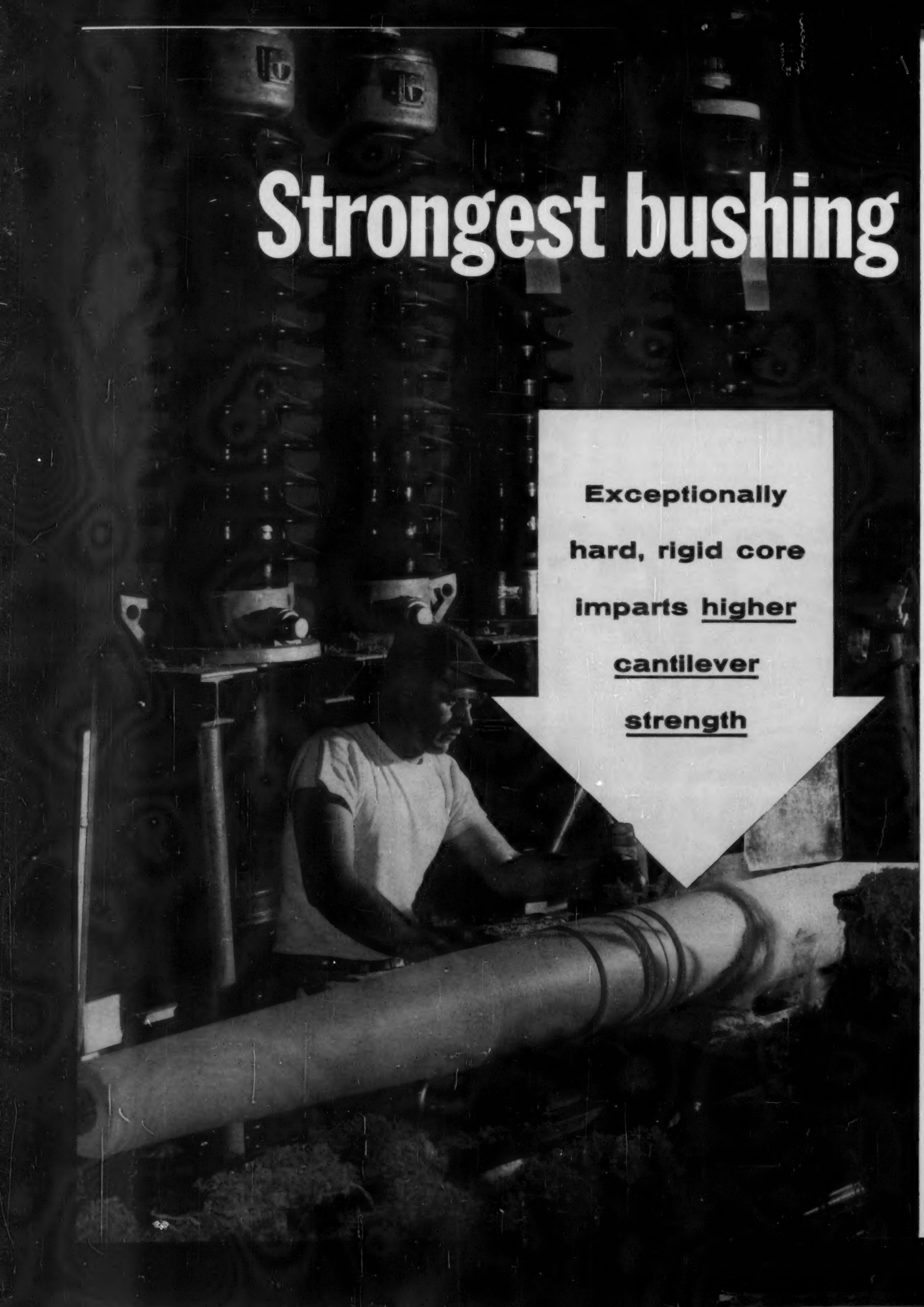

Strongest bushing
Exceptionally
hard, rigid core
imparts higher
cantilever
strength

we've made in 50 years!

Hard, rigid, strong as an oak log - - the insulating core of an O-B condenser bushing. Thousands of layers of paper are compacted into a dense mass on the newest, most modern core-wrapping machines in the industry. Mechanically, this presents an exceptional opportunity.

The practice of merely "floating" the core within its surrounding oil and porcelain housings, supported only at its two extremeties, imposes extra duty on these housings.

O-B design reverses this. Inherent strength of the core is exploited. At strategic points, solid contacts are made between housing and core. The two work together. Cantilever strength factors are materially benefited. Result: the strongest bushing O-B has made in some 50 years of satisfactory field performance in this important category.

Rugged strength helps keep 'ruptor parts in line, and adds to the over-all reliability of circuit breakers. High durability imparts added safety factors to transformers. And - - important in all applications - - this strength gives better assurance of the bushing arriving on the job in factory condition, despite the shocks of transportation and handling.

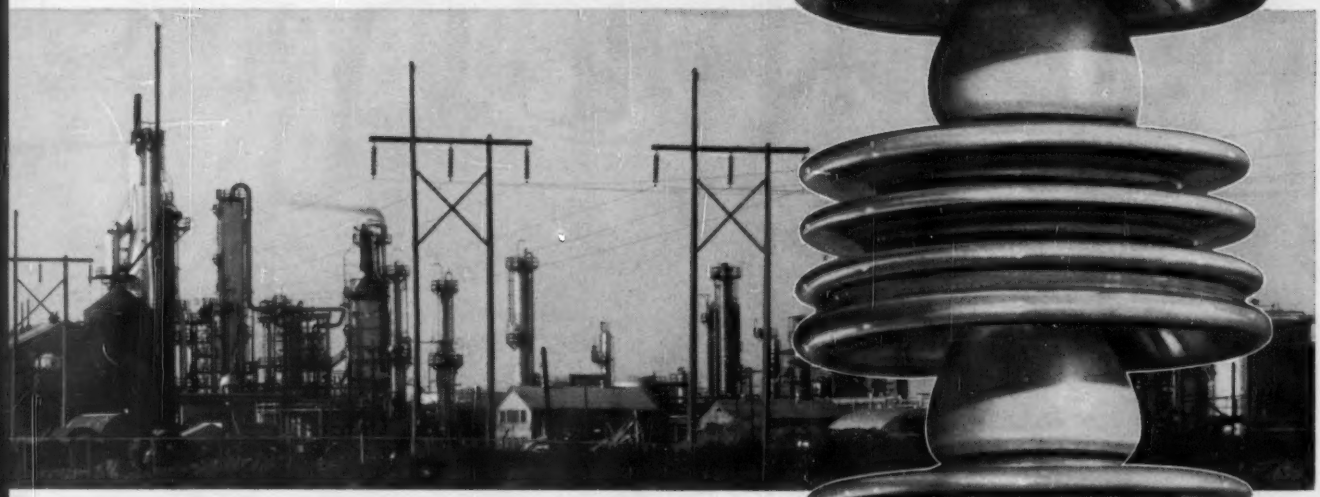
It takes only a word, spoken or written, to get this extra money's-worth. Simply be clear about one thing - - "O-B" - - in requesting the bushings to be delivered with your new station equipment.

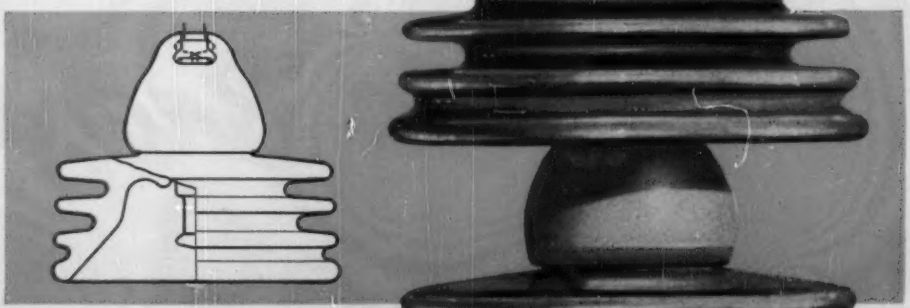
OHIO BRASS COMPANY, MANSFIELD, OHIO

Canadian Ohio Brass Co., Ltd., Niagara Falls, Ont.

Ohio Brass

4912-H





Standard-strength (15,000-lb.)
Lapp Fog-Type suspension unit
for 5¾" or 6½" spacing
either ball-socket or clevis type

High-strength (25,000-lb.)
Lapp Fog-Type suspension unit
for 5¾" or 6½" spacing
either ball-socket or clevis type

Contaminated atmosphere?

USE LAPP FOG-TYPES

THE DESIGN WITH 33 YEARS OF SUCCESSFUL SERVICE

Industrial fumes, salt-spray, dust, even automotive exhaust, continually coat your transmission lines with a conductive deposit. Where these conditions are excessive, prevention of insulator flashover becomes a prime operating and maintenance problem.

Lapp Fog-Type insulators offer a complete answer. Their design (a Lapp innovation more than 30 years ago) provides extra length of leakage path—and a *uniform* leakage path. Maximum exposure to contamination . . . to wetting . . . to cleaning action of wind and rain—distributes voltage evenly, prevents leakage flashover. Even in most areas of severe atmospheric contamination, Lapp Fog-Types require no cleaning—where they do, cleaning intervals are longer, and cleaning easier than on other types.

Forward utility thinking now calls for use of Fog-Type insulation on *all* lines in sea-shore or urban locations; it pays off in improved service records and lowered maintenance costs. And the specification of Lapp Fog-Type Suspension Units adds an extra margin of operating security and trouble-free long life.

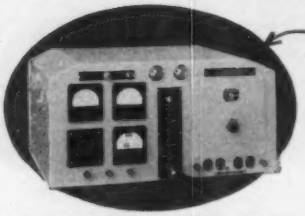
Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp

UNIT CONTROLS PACKAGE SYSTEMS

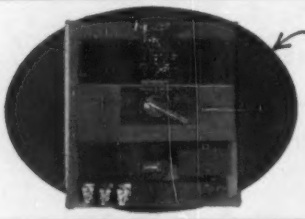
These new Lake Shore Electric developments give you the dependability and economy of simplified design...

with the ruggedness and added convenience of standard components, and NEMA-type housing when specified



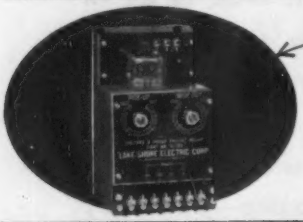
diesel generator control cabinets

Precision AC or DC controls... fully instrumented for trouble-free service. In top-mount, wall-mount, floor-mount cabs to 600 volts 50-60 cycle AC, 250 volts DC.



trans-o-matic transfer switch

This compact safety transfer switch is of mechanically-linked dual circuit breaker design which permits no neutral position. Full relay protection. To 4000 amps, 600 volts.



differential sensing relays voltage — current — frequency

Here's transistor accuracy and printed circuit ruggedness. Adjustable pick-up and drop-out between 70% and 100% of value with only two screw-type adjustments and standard plug-in relay.

autostatic voltage regulator

This rugged transistor design voltage regulator contains no moving parts to cause trouble. Highly accurate and low-cost. Fully warranted for one year. For single generator or parallel service.

where continuous light and power are vital... specify

THE Lake Shore ELECTRIC CORPORATION

207 WILLIS STREET / BEDFORD, OHIO

New Products

(Continued from page 18A)

Secondary Voltage Reference Batteries . . .

A new series of mercury battery packs, designed for use as low-cost secondary voltage standards, can be used instead of cadmium standard cells or regulated power sources to supply constant voltage at good precision in such applications as measuring circuits with resistive transducers, in analog computers as a reference source, in calibration of laboratory and field instruments. Direct voltmeter or vacuum tube voltmeter readings may be made. Packs of any desired voltage can be made up. Each cell has a nominal open circuit voltage of 1.357 volts $\pm 1/2\%$ with a voltage decline of only 1% in 2 years of storage at 70F. Voltage decay approaches an equilibrium and is less than a millivolt in four months or more after a year's storage. **The Mallory Battery Company, a Division of P. R. Mallory & Co., Inc., North Tarrytown, N. Y.**

Silicone Rubber Tape . . .

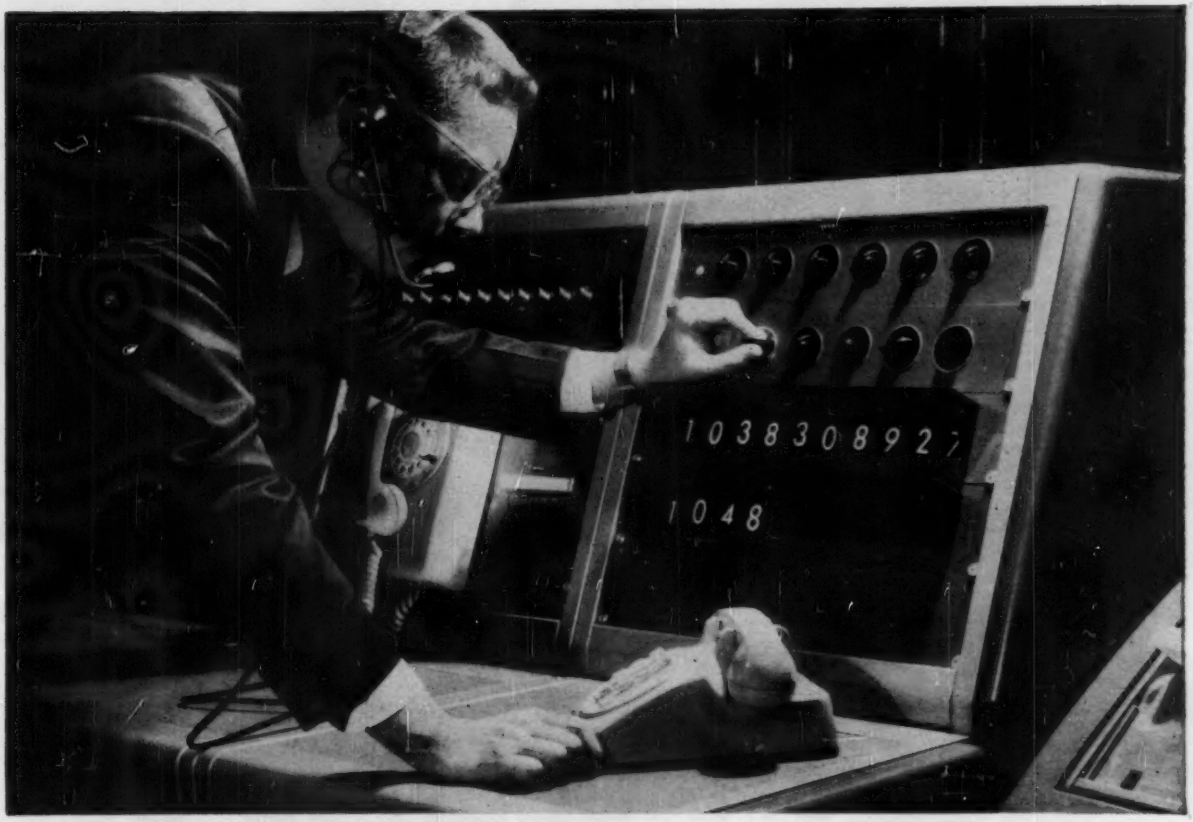
A Class *H*, completely inorganic, unsupported silicone rubber tape handles and feels like plastic tape. Coated with a silicone thermosetting pressure-sensitive adhesive, this tape may be used in splicing silicone rubber-insulated cable, in maintenance of machinery such as diesel locomotives, as a final wrap on stress cones, for insulating leads on large, dry-type transformers, and other applications where neither rubber nor plastic tape meets the requirements of temperature, corona, or arc resistance. Dielectric strength is 700 volts per mil, insulation resistance one million megohms, arc resistance 135 seconds, and elongation 600%. It can be used between temperature limits of —50 C to +180 C. The tape is available on a one-inch core in 18-yard lengths. **Minnesota Mining and Manufacturing Co., 900 Bush St., St. Paul 6, Minn.**

Wide Range, Portable Volt-Ammeter Calibrator . . .

Electrical, electronic, aircraft, instrument, and other manufacturers can use this 20 to 20,000 cycles-per-second volt-ammeter to check their laboratory and portable standard instruments to within $\pm 0.05\%$ accuracy. Manufacturers normally send these instruments to the National Bureau of Standards for periodic recalibration. Current range of this instrument is 50 milliamperes through 5 amperes and a voltage range of 7.5 through 300 volts, both of which can be extended through the use of shunts and multipliers. This unit offers extremely accurate readings because the "null" technique is employed, rather than a conventional direct-deflection indicator. **Charles Engelhard, Inc., 850 Passaic Ave., East Newark, N. J.**

(Continued on page 32A)

MECHANIZED ORACLE EXPLORES BELL SYSTEM COMMUNICATIONS



At monitoring console, designer H. D. Irvin watches performance of "Sibyl" during test of user-reaction to experimental telephones. A computer-like machine, Sibyl simulates the functions of future communications devices and records interplay between phones and users. Sibyl is named after the women oracles of ancient Greece.

A mechanized "oracle" is helping Bell Telephone Laboratories predict the future in communications devices and systems.

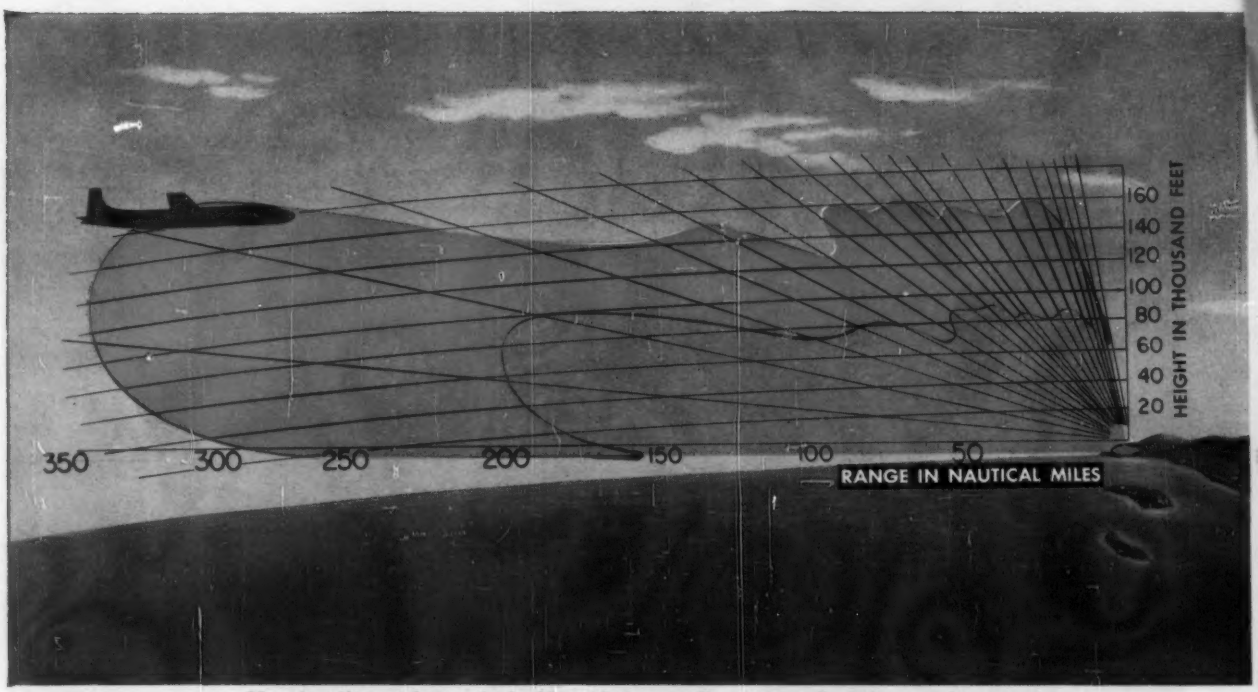
The oracle is "Sibyl," a computer-like machine developed by Bell Laboratories engineers and psychologists. It can simulate the action of many kinds of communications devices. Through Sibyl, new kinds of telephone service can be evaluated without the considerable expense of building actual equipment. Observing and recording users' reactions to the simulated equipment, Sibyl provides indications of how users would react to proposed new systems features and equipment.

Sibyl, for example, is used to test the reaction of Bell Laboratories people to experimental push-button telephones. Each test subject has a push-button telephone in his office and he uses it in the ordinary course of his business. But the set is not connected directly to the local PBX: it is connected *through* Sibyl, which performs the special signaling functions required by such a push-button telephone. In this way, push-button telephone service is given to a group of people without modifying the PBX, or providing completely instrumented push-button telephones.

At the same time, Sibyl gathers information on how the call was placed—date, time, originator, speed of operation, errors, whether the line was busy or the call completed. Sibyl does all this without violating the privacy of telephone conversations.

Bell engineers expect that Sibyl will provide a better understanding of the relationship between telephone equipment and the people who use it. Sibyl's rapid and economical technique for evaluating new types of telephone sets is an important contribution to the art of telephony.

BELL TELEPHONE LABORATORIES
WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT



New Amplitron tube nearly doubles radar range. Copper tone shows increased coverage.

In radar tubes, in breaker contacts, electrically and structurally...

The COPPER METALS meet

THE CHALLENGE OF RELIABILITY

Increased maintenance costs and the increased complexity of most military and commercial products have laid greater stress on the reliability of electrical and electronic components. What the customers want, essentially, is predictable service life without maintenance. The designer faces the problems of temperature, corrosion, material and joint strength, fatigue and many others. His answer is frequently found among the copper metals — whether or not conductivity is also needed. Here are a few design problems where reliability was vital, and where copper or a copper alloy contributed to the solution:

Design Problem—Radar booster tube

Raytheon's Amplitron* is a new type of tube capable of power amplification at microwave frequencies. It boosts the output power of an existing radar installation by 8 to 14 times, and nearly doubles its range. Dependable performance is essential, whether used for military aircraft detection or commercial aircraft guidance. The design problems included extreme mechanical accuracy, durable connections, heat dissipation and vacuum retention. The solution to all of these was oxygen-free, high-conductivity copper.

The anode cavity (diagram above) depends on very tight tolerances for proper performance. Yet in some models it can be formed out of a solid blank of copper by cold forging — with a single press stroke. Copper's malleability makes this possible. The many connections can be brazed reliably because of copper's good joining properties.

With an output above 4 megawatts, heat could be a problem. Copper's thermal conductivity handles it. The good high temperature characteristics of this copper are enhanced by its freedom from oxygen traces, eliminating oxidation, scale formation and conductivity losses. The very high (50-70%) electrical efficiency of the tube depends, of course, on copper's electrical conductivity.

Vacuum retention in a tube of such complex geometry depends on two other characteristics of this grade of copper. The metal is nonporous, and its high purity eliminates the formation of gaseous products. The vacuum envelope is therefore secure, because nothing seeps in and nothing is generated within it.

Raytheon says, *"Without copper, the Amplitron would have been impossible."*

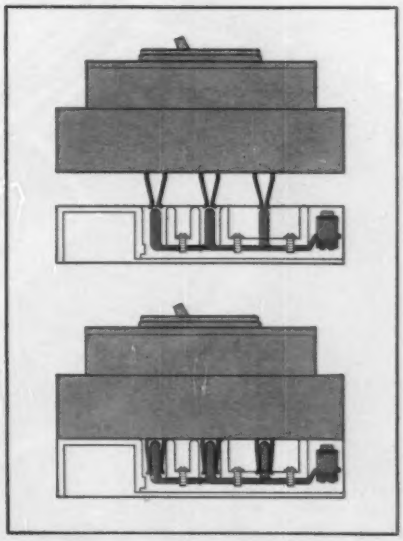
*Raytheon Trade Mark

Schematic diagram of Amplitron tube ➡

Reliable performance depends on conductivity, vacuum retention and accurate fabrication. Copper makes it possible. Complete Amplitron unit shown at left.

Design Problem—Plug-in breaker connections

Federal Pacific Electric Company's "STABreaker" circuit breakers plug right into the panelboard to permit changing units and ratings without bolting and unbolting. Dependable performance of the connectors is essential to circuit continuity and to avoid heating and false tripping. The design problems included high fatigue strength, spring qualities, easy cold working, reliable welded connections and, of course, electrical conductivity. The solution to the problem was found in Phosphor Bronze 5%. The result was an excellent electrical connection and a dependable one.



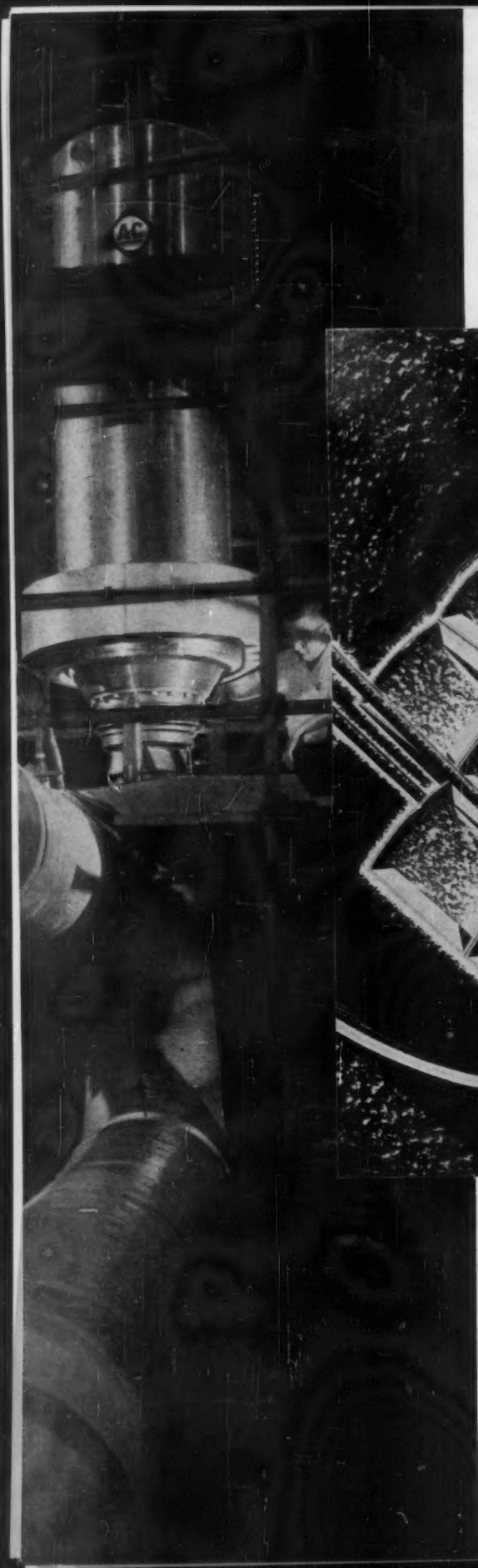
"STABreaker" plugs into panelboard. Enduring spring qualities of Phosphor Bronze 5% assure a reliable contact.

Design Problem—Yours

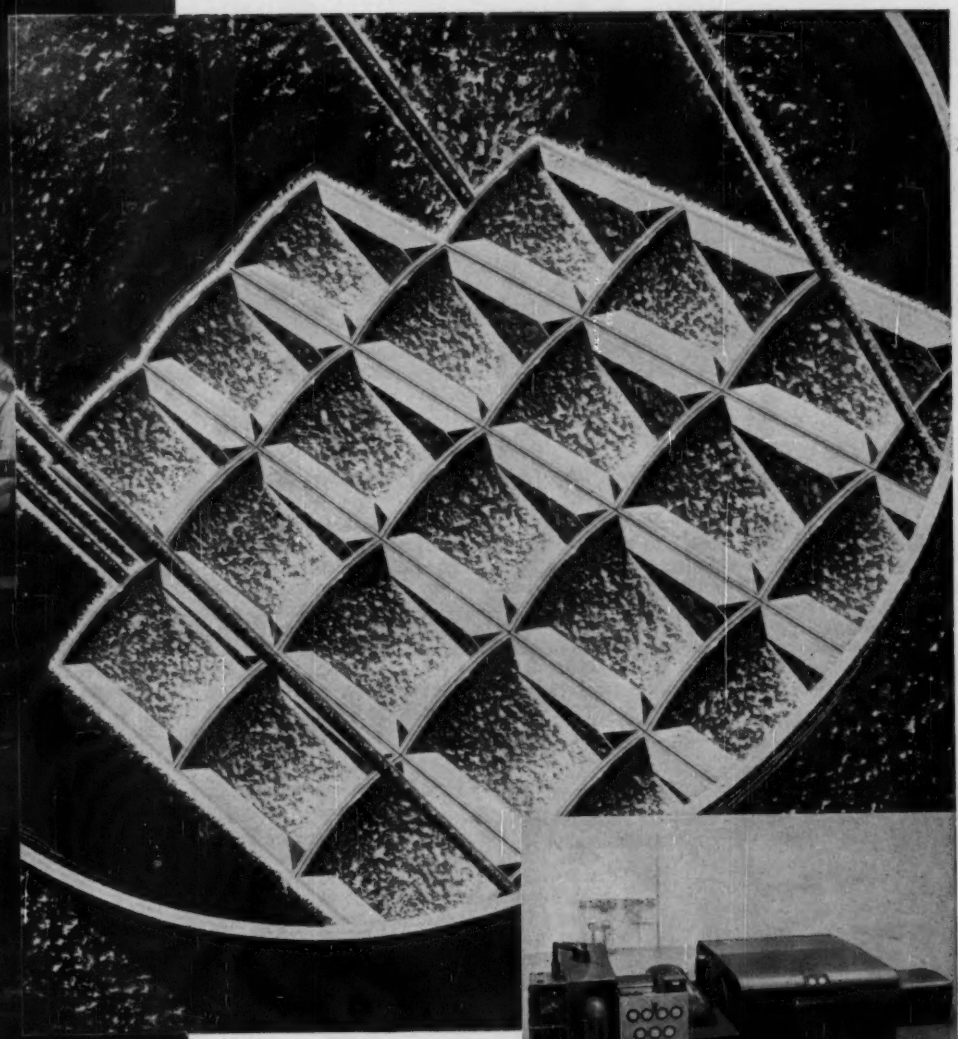
Whenever reliability determines design, the copper metals should be investigated. They have many properties besides conductivity that can help enhance the maintenance-free service life of your product. The Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y., will be happy to cooperate in your investigation.

THERE'S A NEW FRONTIER IN...

COPPER · BRASS · BRONZE



NUCLEAR



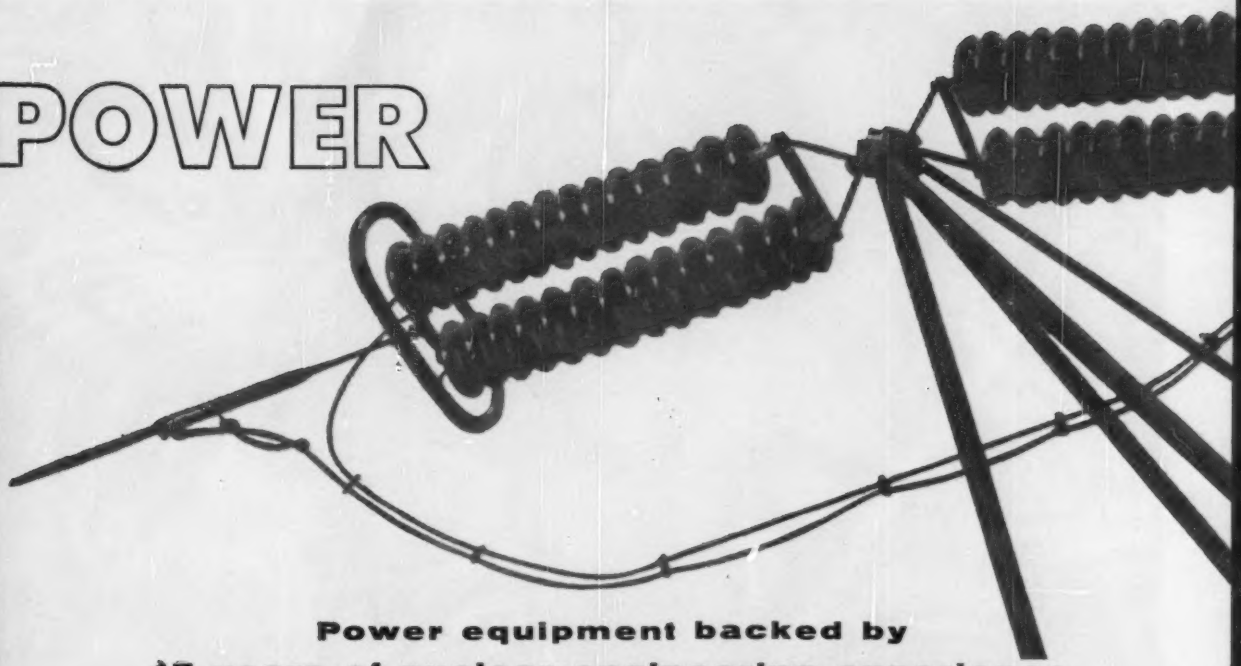
Reactors

Steam Turbine Generators

A-C ALLIS-CHALMERS

A-5790

POWER



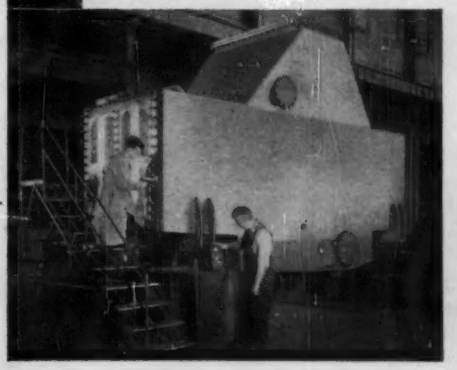
Power equipment backed by
15 years of nuclear engineering experience

ALLIS-CHALMERS development of nuclear reactors and allied equipment is a logical outgrowth of 75 years of building basic power equipment.

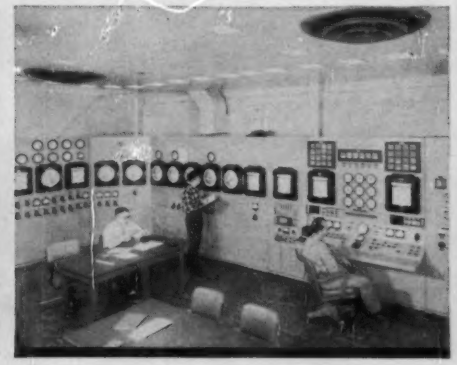
With nuclear experience dating back to the Manhattan Project, facilities, engineering, and production skills are being utilized to produce nuclear power equipment with the same high standards that identify A-C steam turbine generators, condensers, pumps, water conditioning equipment, control, switchgear, breakers, and transformers.

Allis-Chalmers is now engaged in the design and will construct a 66,000-kilowatt nuclear power plant for the Northern States Power Company in cooperation with ten other electric companies.

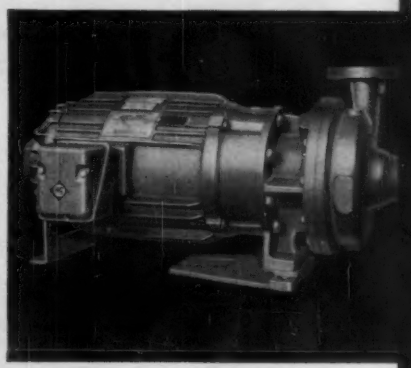
Equipment and engineering for all nuclear power plant needs . . .



Condensers



Control and Switchgear



Nuclear Pumps

ALLIS-CHALMERS

USS Tiger Brand Electrical Wire & Cable

A standard cable for every special job

- Asbestos Wire and Cable
- Mold Cured Portable Cord
- Shovel & Dredge Cable
- Paper & Lead Cable
- Varnished Cambric Cable
- Interlocked Armor Cable
- Special Purpose Wire & Cable
- Aerial, Underground and Submarine Cable

Ends costly pipe-fitting work... simplifies future expansion

Armorlokt - the cable with its own built-in flexible conduit!

Tiger Brand Armorlokt Cables are insulated conductors encased in a flexible metallic armor which is applied at the factory. *Thus you get conductors and conduit in a single integrated unit.* And Armorlokt has a greater current-carrying capacity than conventional wire in rigid conduit.

Their light weight, small diameter and flexibility make them easy to handle—even in long lengths. Costly pipe-fitting work is eliminated.

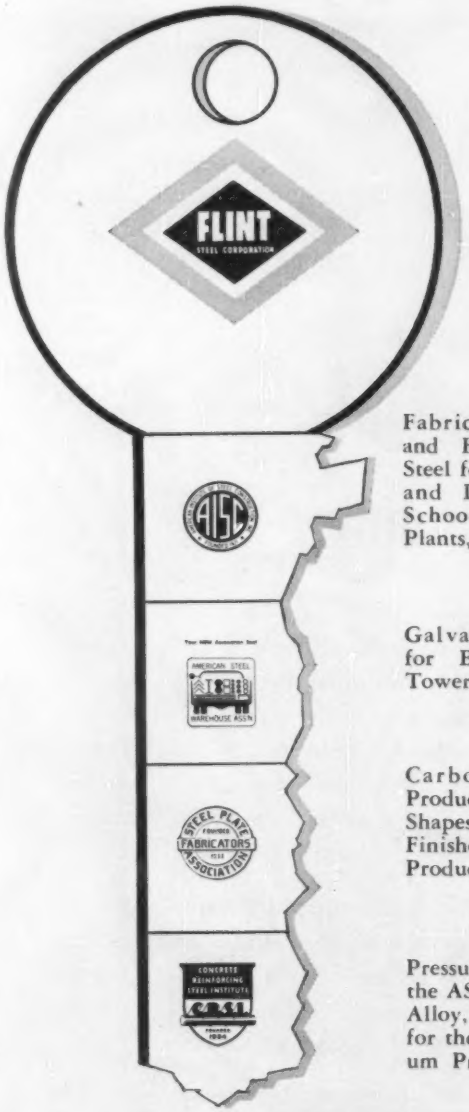
Compared to rigid conduit installation, Armorlokt cables save 55% to 75% in space and can be installed in about half the time. They permit wider latitude in wiring layouts, especially in the expansion or modification of industrial plants or the relocation of machinery. Installed overhead in open racks or trays, Armorlokt Cables are out of the way, yet they are readily accessible for splicing, repairs or maintenance.

Tiger Brand Armorlokt Cables are available in a complete range of sizes and constructions. Just ask your AS&W salesman. Or write direct to American Steel & Wire, 614 Superior Ave., N. W., Cleveland 13, Ohio.

USS, Tiger Brand and Armorlokt are registered trademarks

American Steel & Wire Division of USS United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad



Fabricated Structural Steel and Fabricated Reinforcing Steel for Bridges, Commercial and Industrial Buildings: Schools, Hospitals, Power Plants, Coal Washing Plants.

Galvanized Structural Steel for Electrical Transmission Towers and Substations.

Carbon Steel Warehouse Products: Structural and Bar Shapes, Plates, Hot and Cold Finished Bars, Construction Products.

Pressure Vessels fabricated to the ASME Code from Carbon, Alloy, and Alloy Clad Steels for the Chemical and Petroleum Processing Industries.

The key to successful bidding and a source for steel fabricated to your most exact specifications could be any one or all four of Flint's divisions —

Structural and Reinforcing —

Tower and Substation —

Fabricated Plate

and Steel Warehouse.

Structural steel can now be delivered promptly and when required.

for over 40 years

FLINT STEEL CORPORATION

TULSA . . . MEMPHIS

New Products

(Continued from page 24A)

Safe-T-Generator . . .

Designed to reduce hazards of operation in dust, sleet, snow, and explosive atmospheres, the Delco Safe-T-Generator supplies alternating current without sparking characteristics commonly associated with conventional generators. This is accomplished by completely eliminating the brushes, slip rings, and commutator. Other advantages accruing to the novel design include longer life, and very substantial reduction of maintenance. Furthermore, generator-induced radio noise and interference is virtually eliminated because of the design features inherent in this new concept of power generators. **Delco Products, Division of General Motors, 329 E. First St., Dayton 1, Ohio.**

Electronic Stopwatch . . .

Measures time intervals between opening and closing of contacts on virtually any instrument or control. This unit is available with either glow counter tube or Nixie neon tube readout for direct numerical reading in ± 1 milliseconds accuracy. A range contact time intervals from 2 milliseconds to 10 seconds. Several time intervals may be automatically totaled. **Dynapar Corporation, 5150 Church St., Skokie, Ill.**

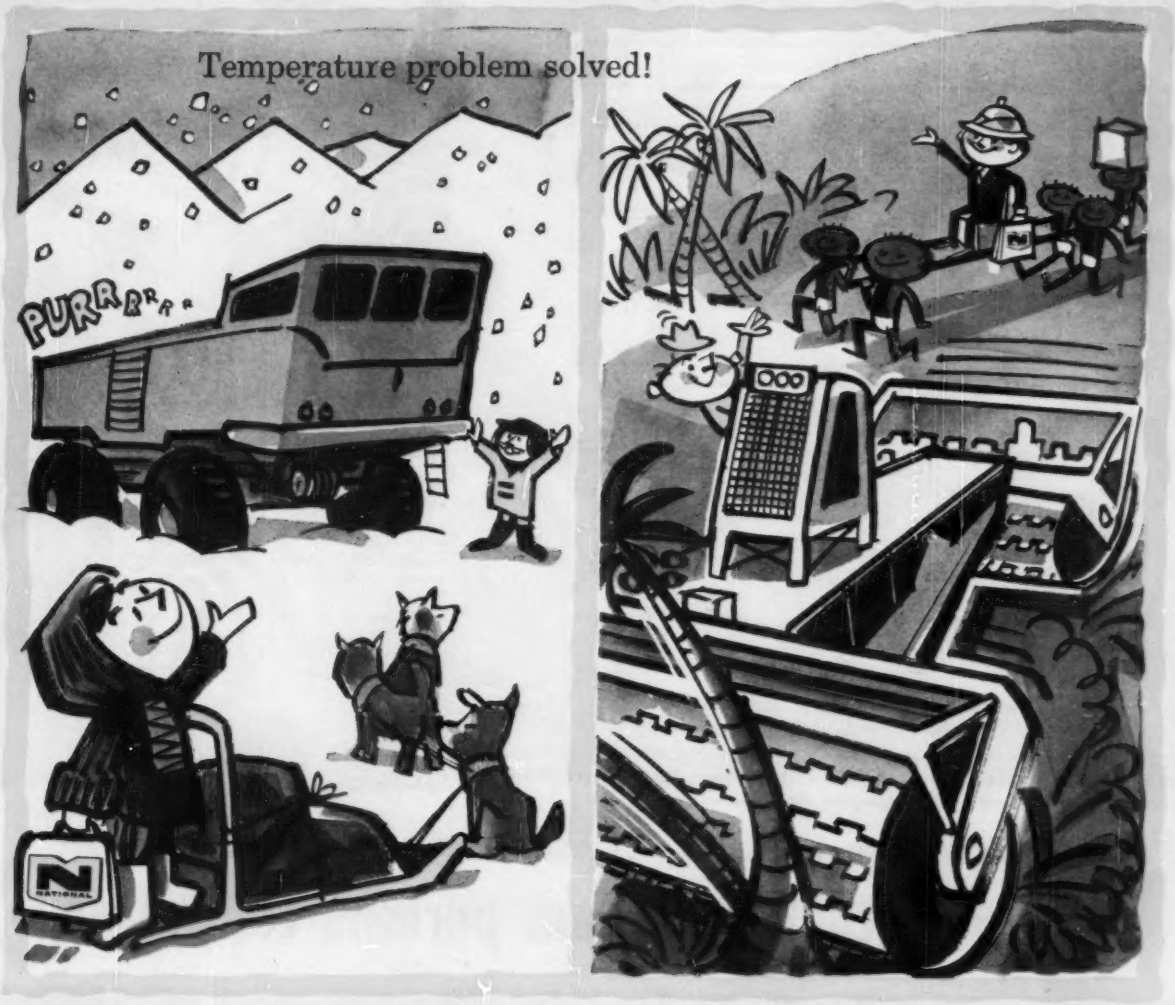
Mercury Lamp with Internal Cutout . . .

The new feature of this 400-watt mercury lamp is a built-in protective device against sudden surges of voltage through the line. This internal cutout eliminates the necessity for costly maintenance trips to replace presently used external film circuit cutouts after heavy electrical storms or other sudden surges of high voltage. The internal cutout allows the lamp to withstand higher voltage surges than do the separate external cutouts used until now. Thus, the lamp is permitted to operate without interruption throughout its normal useful life. **Large Lamp Department, General Electric, Nela Park, Cleveland 12, Ohio.**

Airborne Radar System . . .

An airborne radar system that produces clear, detailed ground maps from behind a protective cover of darkness, clouds, or fog has been developed. This all-weather radar equipment will be used in advanced drone reconnaissance aircraft. Compact enough to be used in most operational aircraft, the lightweight radar system uses a new signal processing technique known as REDAP. **Philco Corporation, C & Tioga Sts., Philadelphia, Pa.**

(Continued on page 38A)



Idling at 70° below zero—or pushing at 127°

one NATIONAL brush fits both jobs!

TRADE-MARK

H. H. FRASCH

These mammoth material movers push, carry, pull and lift over terrain that stops many machines. Working temperatures vary as much as 200 degrees, says H. H. Frasch, "National" Carbon Brush Man.

Rugged brushes are vital, Frasch continues, because each wheel is geared directly to a high torque DC motor.

For motors and generators, the manufacturer chose "National" Brush grade SA-45. RESULT: excellent cold weather performance, even under idling and stalling loads—excellent tropical performance, even where commutator speeds reach 5,000 RPM.

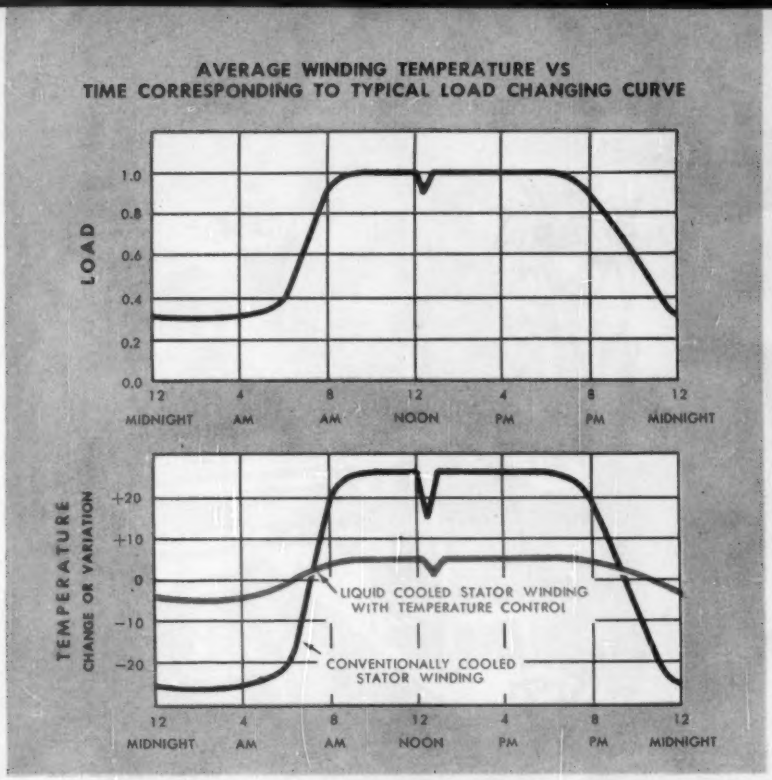
Further, NATIONAL CARBON'S one-brush solution simplified brush ordering and gave the customer maximum quantity discounts. Call *your* "National" Brush Man next time you have a problem or write to National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

"National", "N" and Shield Device, and "Union Carbide" are registered trade-marks of Union Carbide Corporation

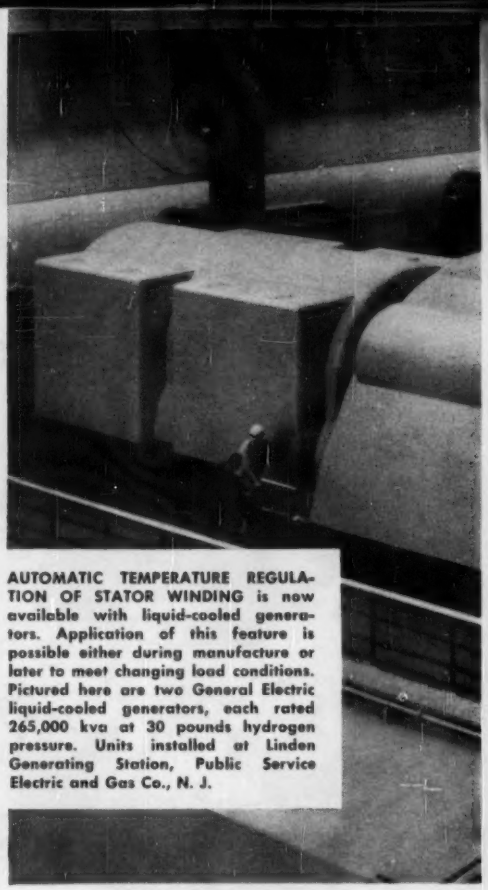
UNION CARBIDE

NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N.Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto



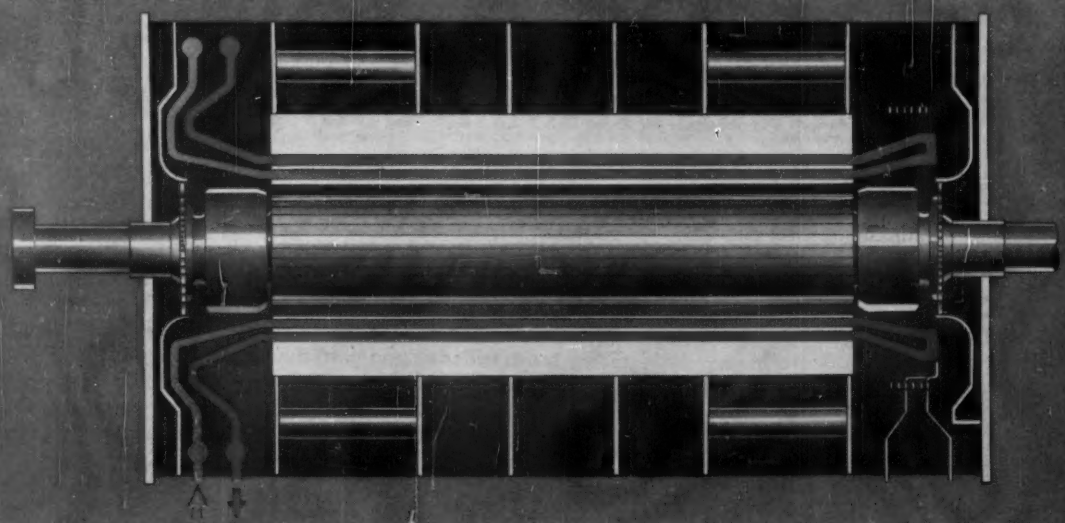
MINIMUM VARIATION OF STATOR TEMPERATURE is possible with liquid cooling, in spite of changes in generator load. Since the liquid coolant is in direct contact with the hollow conductors, the temperature difference between them is only a few degrees. Therefore, by thermostatic control of the coolant, average copper temperature can be kept essentially constant, thus minimizing thermal stress cycling on the insulation.



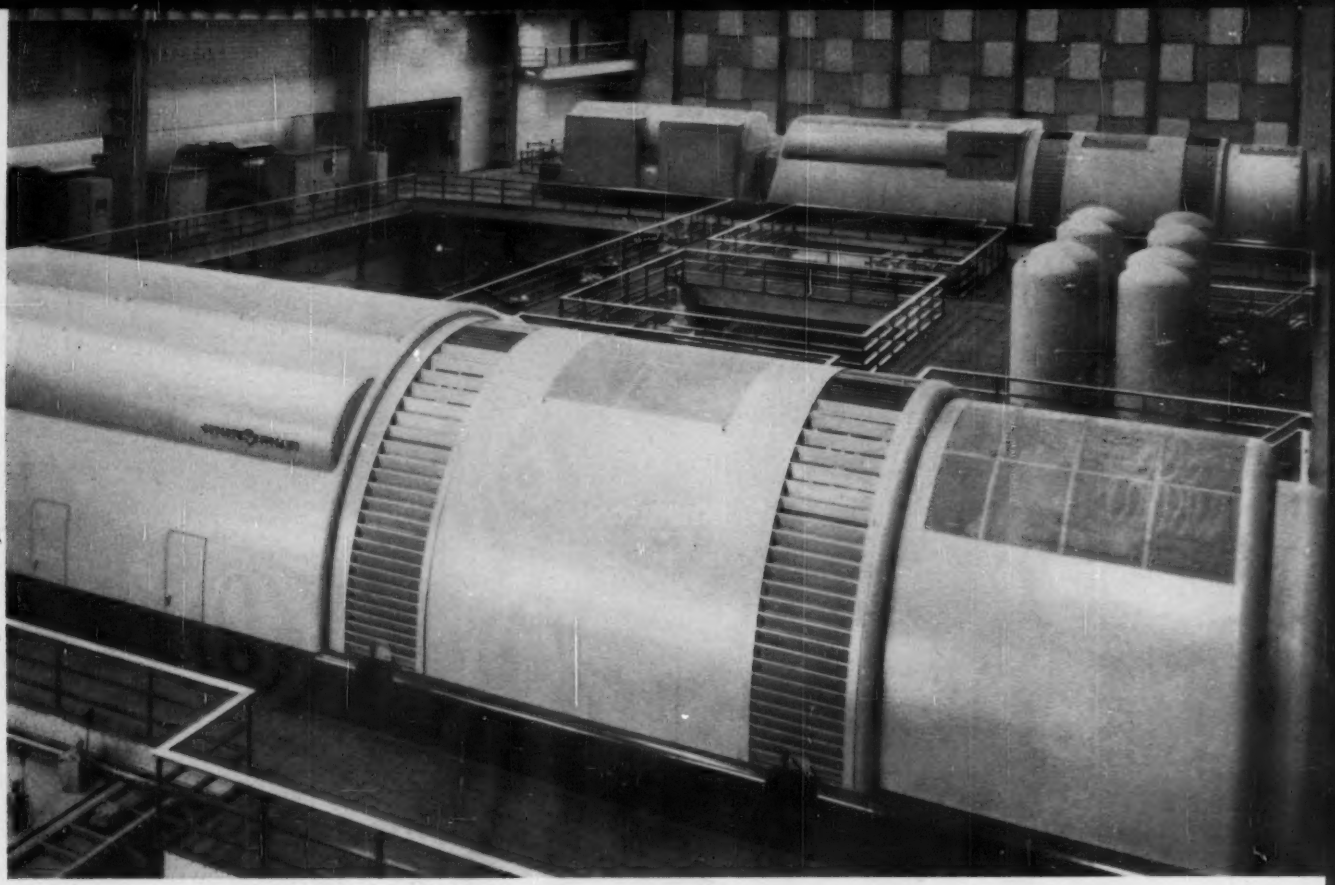
AUTOMATIC TEMPERATURE REGULATION OF STATOR WINDING is now available with liquid-cooled generators. Application of this feature is possible either during manufacture or later to meet changing load conditions. Pictured here are two General Electric liquid-cooled generators, each rated 265,000 kva at 30 pounds hydrogen pressure. Units installed at Linden Generating Station, Public Service Electric and Gas Co., N. J.

WITH HIGHER RATINGS NOW POSSIBLE FOR GENERAL ELECTRIC GENERATORS...

Liquid cooling system permits control of



SIMPLICITY OF THE LIQUID FLOW CIRCUIT adds to reliability. As shown here, highest copper temperature is near the end of the bar, making possible automatic regulation of stator temperature by regulating the flow and temperature of the inlet coolant. Automatic throwover features in the pumping system and other protective devices all contribute to the dependability and continuity of operation of liquid-cooled generators.



stator winding temperature independent of load

REDUCED THERMAL STRESSES HELP EXTEND INSULATION LIFE

In addition to the greater capacity available with liquid cooling, generators may be operated in essentially the same manner established by the successful operation of more conventional machines.

The liquid-cooling system permits generator output to be increased or decreased with minimum variation of stator winding temperature. Since the cooling liquid at the outlet reflects within a few degrees the actual maximum copper temperature of the bars, the inlet coolant temperature may be regulated—automatically—to maintain copper temperature almost constant, regardless of load.

Longer insulation life is the result, since with uniform stator temperature there is much less expansion and contraction of the stator bars. Automatic regulation of stator temperature can be applied most effectively to liquid-cooled machines either during manufacture or later, if desired. This is just one of the many important features of General Electric liquid-cooled generator stators. Other outstanding features are:

***Increased Generator Output**—Hollow strand stator bar construction can remove up to 16 times more heat than conventional cooling arrangements, permitting higher generator ratings.*

***Maximum Efficiency**—Little power is required to circulate the coolant; also a larger cross-section of copper is provided in the winding.*

***Design Simplicity**—Dielectric system maintains the simplicity and dependability of conventionally-cooled machines.*

***Dependable Operation**—Many unique features are incorporated into the design of the closed coolant system to provide a permanently tight liquid circuit.*

***Shorter Maintenance Inspections**—Simple, single-stage, low-pressure hydrogen circulating fans facilitate disassembly and inspection.*

For more information on liquid cooling, contact your nearest Apparatus Sales Office or write for bulletin GER-1231, Large Steam Turbine-Generator Department, General Electric Company, Schenectady 5, N. Y.

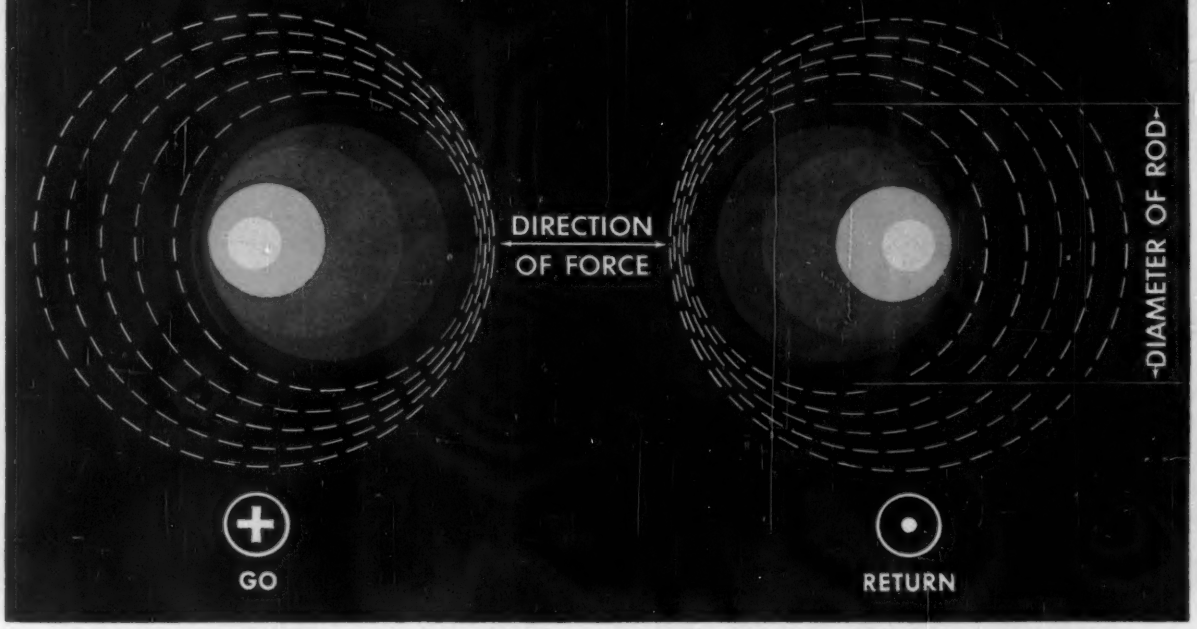
254-74

Progress Is Our Most Important Product

GENERAL ELECTRIC

Factors in bus conductor design

Skin and proximity effects



Dotted lines indicate magnetic fields. Color shading illustrates the resultant distribution of alternating current in round rod conductors. Mechanical force is developed as the centers of current try to move into the centers of their magnetic fields.

Low skin-effect ratio favors tubular shape

Skin effect becomes increasingly important in the medium and larger sizes of bus conductors carrying alternating current. It is the basic reason for using tubular conductors, quite apart from the structural advantages which they also possess. Tubular shapes (round or square) and paired channels have low skin-effect ratios, i.e., low effective resistance to alternating current.

Skin effect is, essentially, the crowding of the main alternating current flowing in a conductor toward the outside surface by a contrary flow induced in the center of a solid conductor, a cable, or in the inner annular area of a tubular conductor by the constantly varying magnetic flux surrounding it.

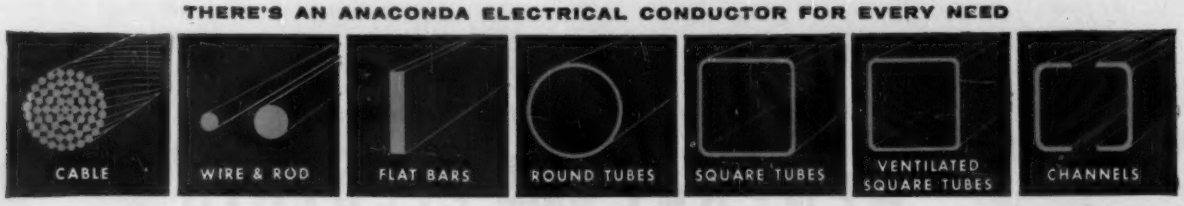
Proximity effect is uneven distribution of an electrical current over the cross section of a conductor due to distortion of the surrounding magnetic field by the field or fields generated by current in neighboring conductors. The practical result of "proximity" is an increase in the apparent resistances of the conductors affected. Mechanical forces also are generated.

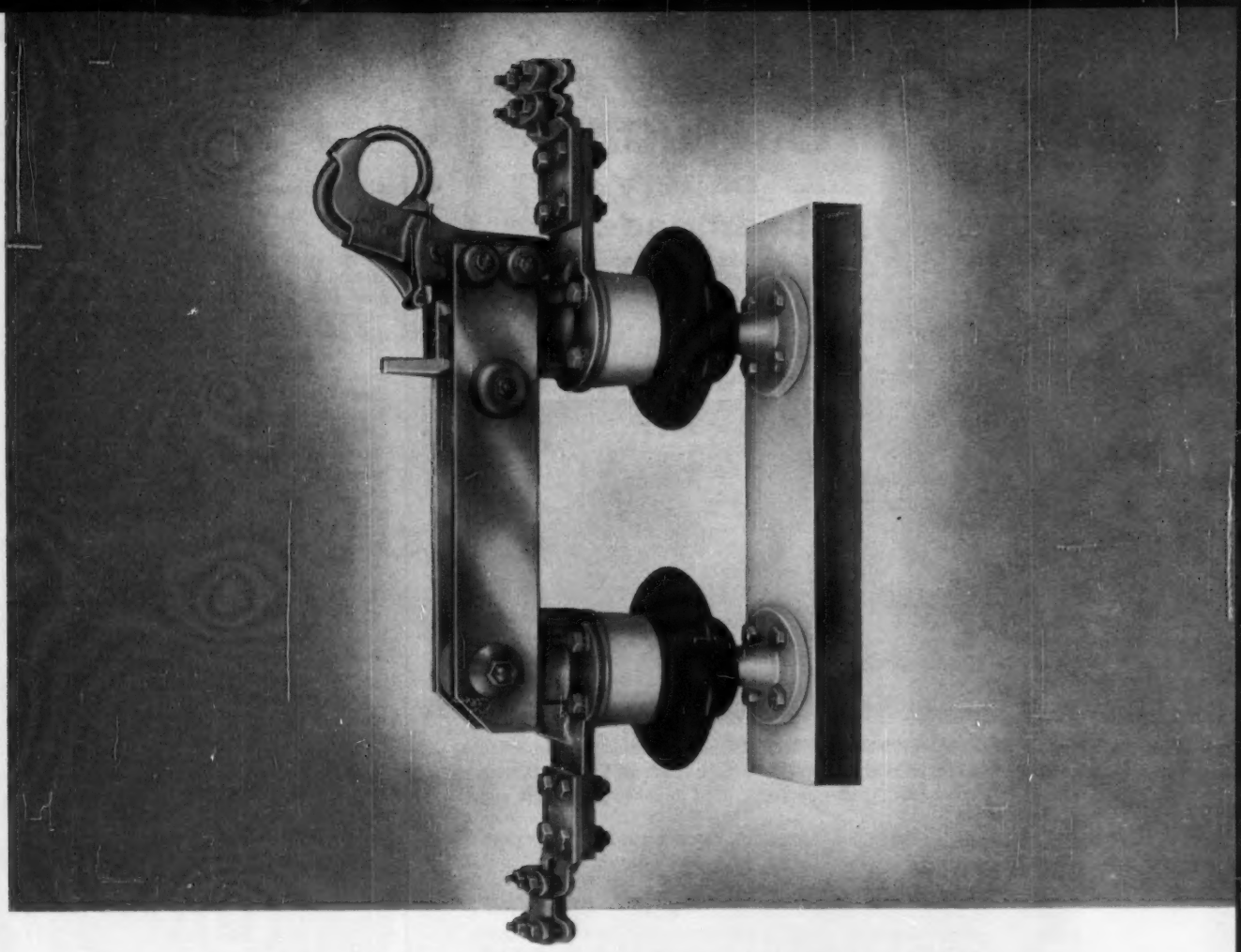
Field and current distribution problems are two of the many which complicate bus design. The Technical Department of The American Brass Company is always available to engineers for consultation in the selection of Bus Conductors for specific needs. See your Anaconda representative, or address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

6001

ANACONDA® COPPER CONDUCTORS

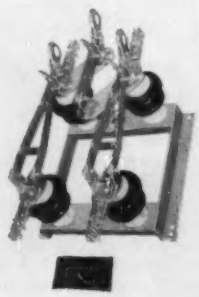
THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED





There is an Important Difference in this Southern States Disconnect

TYPE PBO-R



This regulator by-pass switch offers a compact unit that provides disconnecting means needed to by-pass and isolate voltage regulators. Available in ratings of 7.5 — 15 kv — 400, 600, and 1200 amps.

All hookstick-operated disconnects are simple devices. There are no intricate mechanisms — nothing complicated in their design or construction.

Certain highly desired features are fairly well standardized on disconnects being marketed today: positive latching of the blade in its closed position; a blade pryout; guides to position the blade when closing; and high pressure line contacts.

Yet there is an important difference in disconnects!

You can't see it feature by feature. It is apparent only when you take a good, studious look at the complete unit. For then you see how all of the features blend together to give you a sturdy, rugged and highly dependable piece of equipment.

Take a look at the Southern States PBO Disconnect illustrated above and you'll see what we mean.

For the full story, see your Southern States representative, or write for Bulletin 55 PBO.

LIVE BETTER ELECTRICALLY

SOUTHERN STATES
EQUIPMENT CORP.
HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

At New England Electric's Salem Harbor Plant . . .

"Our *NICAD* battery has needed *NO WATER* in over 6 years"

In 1951 this 125-volt NICAD Nickel Cadmium battery was installed in the new Salem Harbor station of the New England Electric System where it is the normal source for circuit breaker operation and valve motors.

It also provides standby power for clock recorders, indicating lamps, motors for main turbine seal oil and bearing oil pumps, and for station lighting in emergencies.

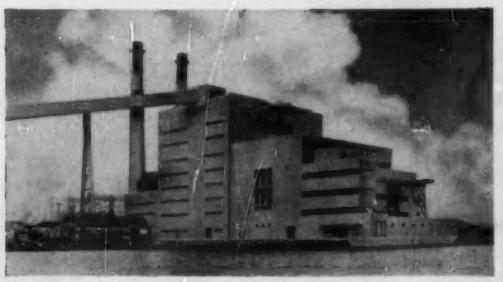
After this battery had been in operation for six years, a regular annual inspection found it to be in excellent, "like-new" condition . . . and no water additions had been necessary since installation!

Such outstanding records of reliability and economy are not uncommon with NICAD batteries. They perform better over a wider temperature range than other types of batteries . . . will not freeze in any state of charge . . . give off no corrosive fumes.

Combine these advantages with those of long life, rugged construction, and long-term economy through uninterrupted service, and you see why use of NICAD batteries assures the most reliable performance at the lowest annual cost.

Ask us for more information on NICAD storage batteries.

New England Electric's Salem Harbor Plant



NICAD DIVISION

GOULD–NATIONAL BATTERIES, INC.

Easthampton, Massachusetts

New Products

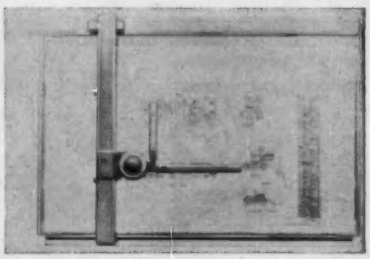
(Continued from page 32A)

All Electronic Transistorized Digital Voltmeter . . .

Accuracy and resolution of this Model *81* digital voltmeter is 0.015% over the three automatically switched ranges of ±10, ±100, and ±1,000 volts d-c. Input impedance of the instrument is 10 megohms at all times, even when digitizing and under conditions of overload. Primarily intended for automatic measurement, display, and recording of voltages in digital form, the Model *81* is ideally suited for use in applications such as production testing, precision research measurements, telemetry, and alarm monitoring. **Beckman Instruments, Inc., Systems Division, 325 N. Muller Ave., Anaheim, Calif.**

The Tracmaster . . .

The Universal Tracmaster (registered trademark) is an X-Y track drafting machine that provides graduated track settings, in addition to all the usual angular and dimensional measurements possible with the customary drafting machine protractor and scales. On each track, numbered graduations are provided at precise 10-inch intervals for quick, easy reckoning.



In effect, these track graduations divide the entire drawing area into a 10-inch grid pattern. This is extremely useful for accurately establishing widely separated reference points, or measuring and drawing long lines, with no cumulative error due to the repeated scale extensions necessary with standard type drafting machines. **Universal Drafting Machine Corporation, 7960 Lorain Ave., Cleveland 2, Ohio.**

Terminal Block . . .

A redesigned terminal block eliminates the time consumed by dropped and lost screws. A spring clip has been added on each terminal to retain the screw when backed out, yet permits deliberate removal whenever desired. The new Type *RH* terminal is rated at 750 volts, 50 amperes, and is available from one to 20 terminals for use with American Wire Gauge No. *8* to No. *18* wire. **Curtis Development & Mfg. Co., 3250 N. 33rd St., Milwaukee 16, Wis.**

(Continued on page 46A)

the challenge of new frontiers

Here in the West, where sweeping plains and lofty mesas once challenged the conquistadores of New Spain, Sandia Laboratory now explores new frontiers of science and engineering—seeking the answers to vital questions in many areas of knowledge.

Sandia Corporation was established in 1949 to perform research and development in the ordnance phases of nuclear weapons for the Atomic Energy Commission. This is still our main task, but in doing it we have learned much in the way of theory and advanced technique that has application outside the field of weaponry. For example, Sandia Corporation, working in support of the AEC's nuclear physics laboratories, is currently studying problems concerned with the non-military uses of nuclear energy and with techniques involved in the control of thermonuclear reactions.

Approximately 1,800 engineers and scientists work with the support of 5,700 other employees at our laboratories in Albuquerque, New Mexico, and Livermore, California. These laboratories are modern in design and equipment, with permanent facilities valued at $65,000,000. Equipment available, or in the process of installation, includes an electron and positive ion Van de Graff accelerator, a 5-megawatt tank-type heterogeneous nuclear reactor, a wind tunnel operating in subsonic through hypersonic ranges, digital and analogue computers, and various devices developed for specialized uses. Extensive test facilities are provided for the research and development engineer for proving design theories and concepts.

Engineers, mathematicians, and physicists—particularly those with advanced degrees—will find many new and challenging frontiers at Sandia in the fields of fundamental and applied research; design and development; aeronautical, manufacturing, reliability, and test engineering; and quality assurance.

Sandia's liberal employee benefits include our graduate educational aid program, life insurance, sickness benefits, retirement plan, and generous vacations. These combine with excellent working conditions to make Sandia an exceptionally attractive place to work.

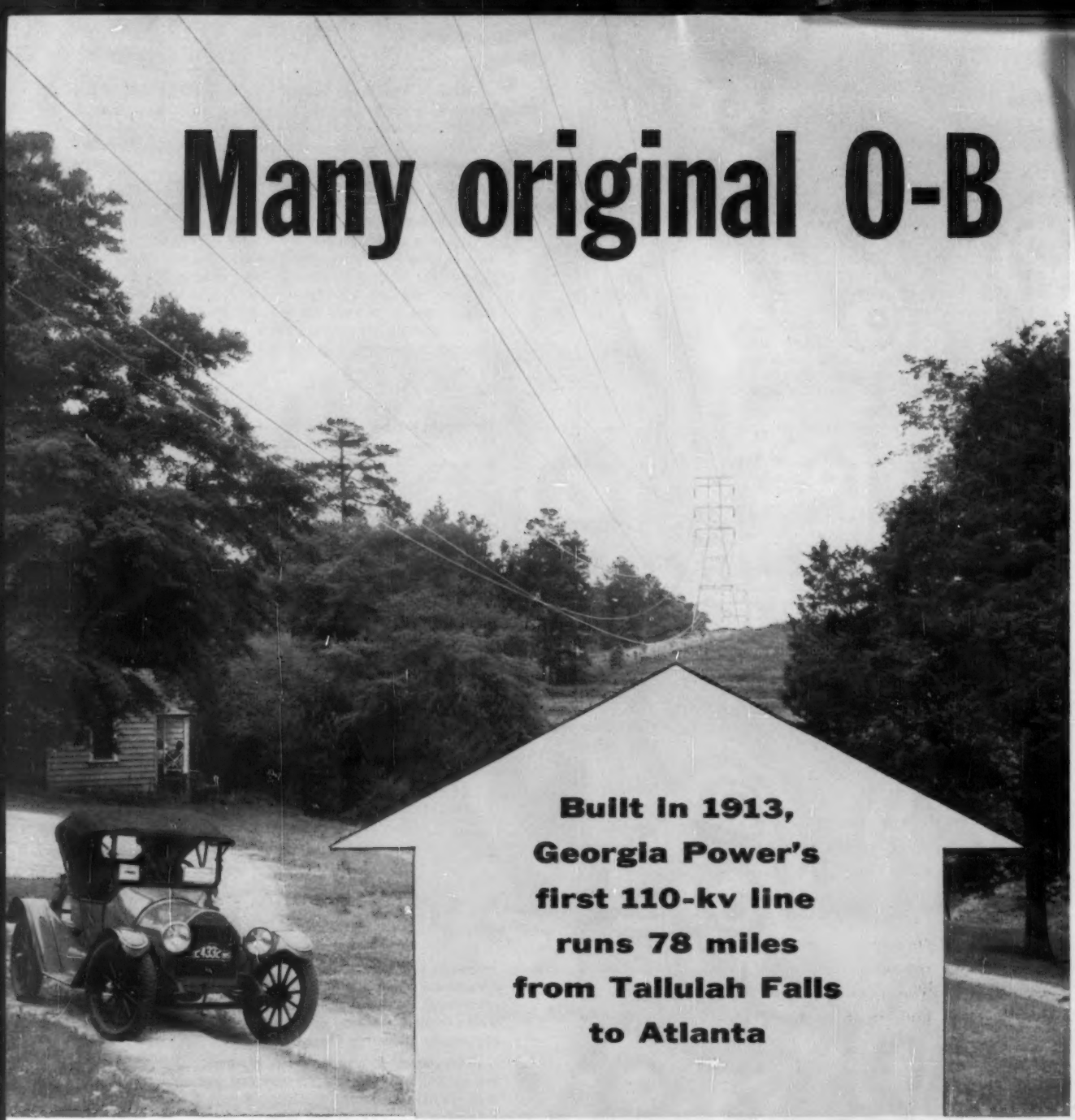
Albuquerque is a modern city of about 225,000 people, known for its excellent recreational attractions and its mild, dry, sunny climate. Livermore, located in the San Francisco Bay area, offers suburban advantages close to metropolitan San Francisco. Both are fine places in which to live.

Our illustrated brochure will tell you more about Sandia Corporation and the opportunities it offers to engineers and scientists. Write for your copy to Staff Employment Section 551D.

SANDIA CORPORATION

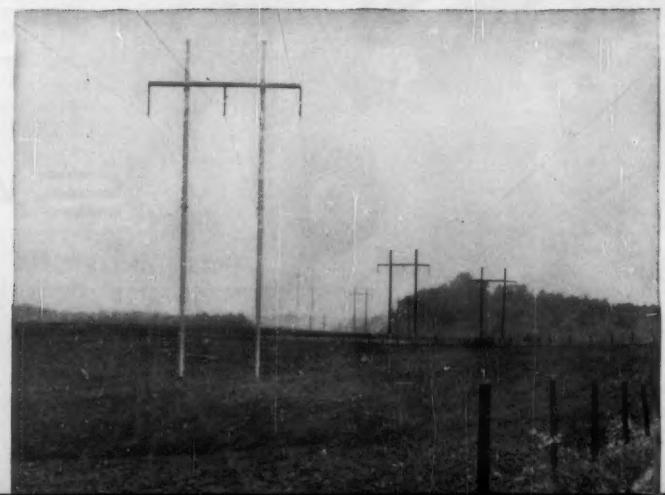
ALBUQUERQUE, NEW MEXICO

Many original O-B



Built in 1913, Georgia Power's first 110-kv line runs 78 miles from Tallulah Falls to Atlanta

886-H



Modern 230-kv and 110-kv lines are still built with O-B insulators.

insulators still serve

When Georgia Power built its 110-kv Tallulah Falls line from a hydroelectric site in northeast Georgia to Atlanta, there was considerable doubt as to whether the Company would ever be able to sell all the power that the 60,000-kw of generating capacity at Tallulah Falls provided.

There was also some concern about the new suspension insulators of that day. Considerable technical data, backed by laboratory experience, indicated the new O-B design was a good one.

But proof of performance was lacking.

Now there is proof in abundance, and probably no better proof than a look at the Tallulah Falls line as it is today.

Tallulah Falls Today

The insulator design that was looked upon with skepticism in 1913 has become the industry standard of today. Many of the O-B suspension units installed during the line's early years are still in service. No longer is the 110-kv line, built in 1913, the backbone of the transmission system. The company that was worrying about building load for its 60,000-kw plant at Tallulah Falls in 1913 now has a system capacity of 1,813,000 kw.

New Transmission Lines at Georgia Power

Comparing the Tallulah Falls design with the 110-kv lines built with steel towers since World War II shows surprisingly little difference. But in more recent years, most of the 110-kv construction has been on wood H-frame towers.

On its new 230-kv lines, Georgia Power has been using guyed tubular steel towers. Each pole on the line consists of two sections of tapered steel tube bolted together. Conductors are supported from a steel channel crossarm.

Modern O-B suspension insulators are still standard for both 110-kv and 230-kv construction.

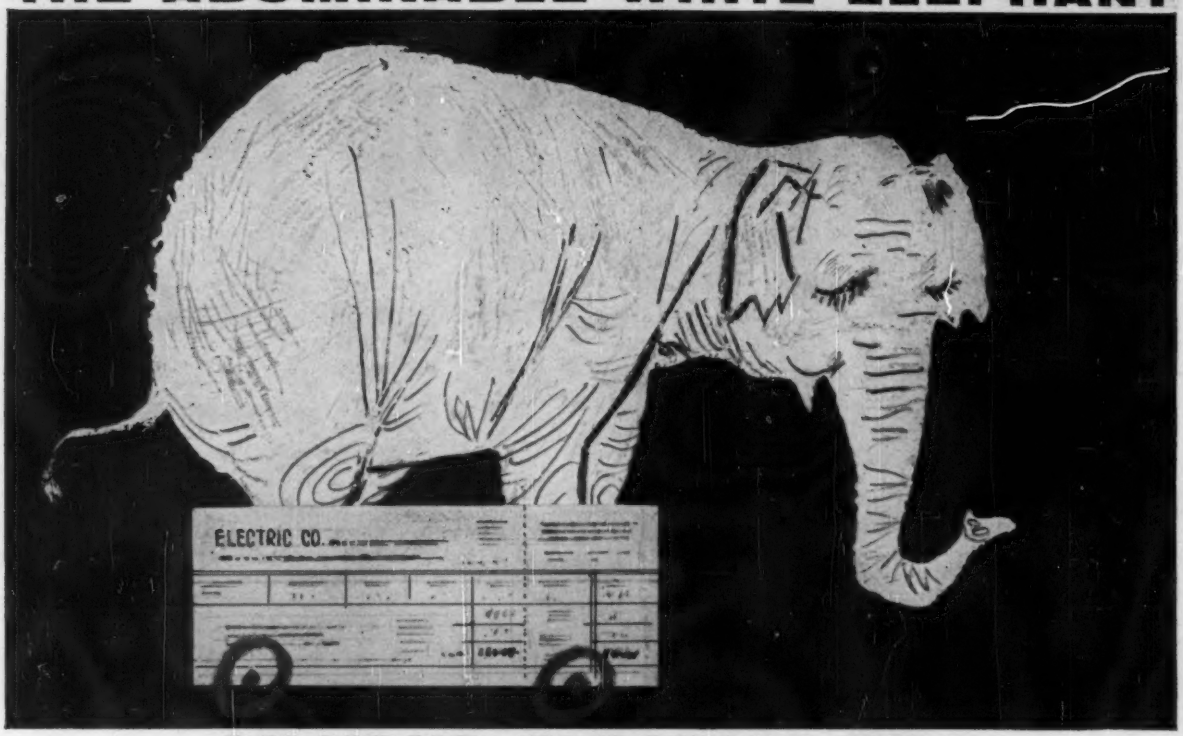
And what about the Tallulah Falls plant, the one that supplied too much power in 1914? Now power flows from Atlanta to the plant because the area around Tallulah Falls needs more power than the plant can supply.

OHIO BRASS COMPANY, MANSFIELD, OHIO

Canadian Ohio Brass Co., Ltd., Niagara Falls, Ont.

Ohio Brass

THE ABOMINABLE WHITE ELEPHANT



ON YOUR ELECTRIC BILL

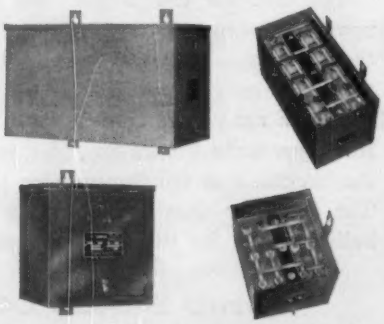
IF YOUR ELECTRICAL SYSTEM is burdened with a low power factor, you're paying for electricity you can't use... you're giving up electrical capacity you may need.

The motors and other inductive devices in your plant use both kilowatts (working current) and kilovars (magnetizing current) in order to run. The kilowatts you buy. The kilovars you can best supply yourself. *The more you supply, the higher your power factor, and the less you pay the electric company.*

Sprague Unipak* Power Factor Correction Capacitors are the most economical and efficient means of supplying your own kilovars. You put them right where they're needed . . . *at the motors.* Your electric company does not have to send as many kilovars all the way from the power plant, so they charge you less. Your wiring does not have to carry the extra kilovars to the load, so it can handle additional loads.

Actual power bill savings experienced in many plants have more than paid for the Power Factor Capacitors in less than a year's time . . . in some cases, in less than six months. And as an added dividend, these capacitors have also increased the power handling capacity of many plant distribution systems by an average of 20%.

You, too, can reduce costs . . . increase your plant's electrical capacity . . . by installing Sprague Unipak® Power Factor Correction Capacitors.

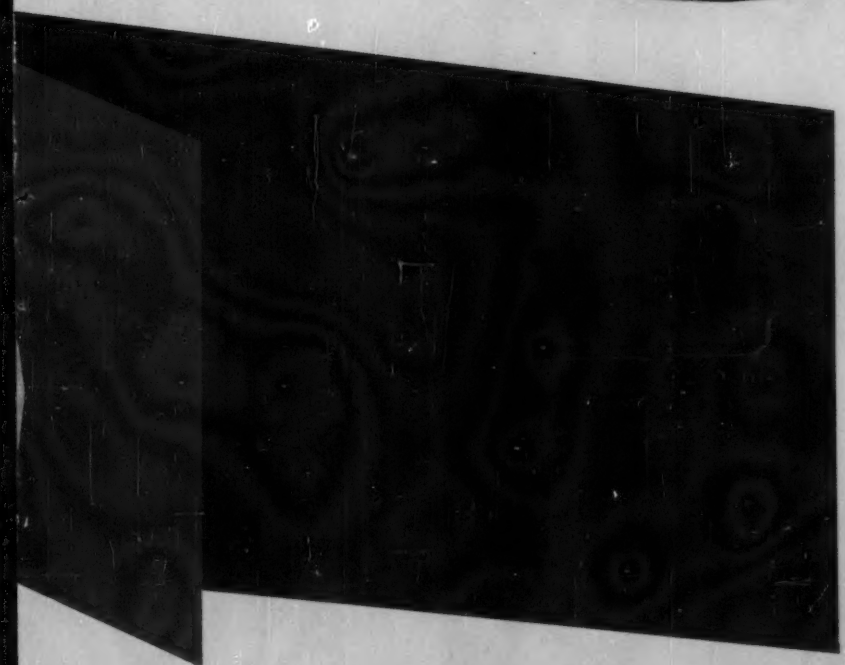


If you'd like *free* assistance in making a survey of your electrical installation to see how *you* can save money with Sprague Unipak* Power Factor Capacitors, write Industrial Capacitor Division, Sprague Electric Co., 321 Marshall St., North Adams, Mass.

*Trademark

SPRAGUE®
the mark of reliability

WORLD'S LARGEST
CAPACITOR MANUFACTURER



—first step to better coil design

Manufacturers of electromagnetic equipment can reduce material and production costs *now*—by switching to ALCOA® Aluminum strip windings. Equipment designed with ALCOA strip is more compact, lighter in weight, and better able to dissipate heat than conventional wire. For information about recent ALCOA developments in this field and how they benefit you —please turn the page.

NEW DESIGN CONCEPTS WITH ALUMINUM STRIP

by Robert R. Cope, Aluminum Company of America, Pittsburgh, Pa.

Light weight, better space factor, better heat dissipation, low voltage between turns, less point-to-point contact . . . these characteristics of aluminum strip have long intrigued designers of electrical windings. Today, this aluminum application is a practical reality.

Intensive research and testing by ALCOA have contributed to important technical breakthroughs. New techniques are solving problems relating to edge effect, joining and insulation.

Recently, ALCOA purchased the transformer division of Automation Instruments, Inc., to perfect winding techniques and to produce prototype coils for customers' evaluation. With this added facility, the electrical windings division of ALCOA Research Laboratories is equipped to wind coils from small solenoids up to distribution transformer sizes for testing by manufacturers—an important, new service for the electrical industry.

ALUMINUM'S NATURAL ADVANTAGES

Aluminum weighs less. In general, an aluminum strip winding weighs only half as much as an equivalent winding of copper. Based on equal current-carrying capacity, 0.48 pounds of aluminum replaces one pound of copper. (Figures are for 61.0 per cent conductivity aluminum, 97 per cent conductivity hard-drawn copper.) ALCOA No. 3 EC alloy has been developed expressly for electrical windings. Space factor of aluminum strip can be 90 per cent and higher; for copper wire, 55 per cent to 65 per cent is typical. Thus, although an aluminum strip requires more conductor volume than a conventional wire winding, the total space occupied by each is about the same. Variations in space factor will depend on the strip-to-insulation thickness ratio.

Aluminum strip windings permit higher current densities because each turn has an outside radiating edge that provides effective heat dissipation. Layer-to-layer temperatures are constant; hot spots are virtually eliminated. The inner turns of a wire-wound coil cannot radiate heat as efficiently as the outer turns.

In most cases, aluminum strip windings can be manufactured at lower cost than equivalent wire windings. Aluminum strip lends itself to automation; new high-speed winding techniques have reduced fabrication costs by eliminating much of the hand labor necessary with wire.

Conventional wire windings require heavier insulations to withstand (1) abrasion during winding, (2) abrasion from point-to-point contact between turns, (3) layer-to-layer voltage, which may be many times the turn-to-turn voltage. Aluminum strip insulation needs to withstand only turn-to-turn voltage because a single turn occupies the entire width of the coil. Thus, thinner and less abrasion-resistant insulations can be used, such as interleaved sheets of Mylar or Kraft paper . . . coatings of varnish, lacquer or epoxy . . . anodized films or vitreous enamel.

ALCOA has tested every known method of joining aluminum. Some techniques proved impractical or costly. But successful joining has been accomplished with ultrasonic welding, high temperature soldering, shielded inert arc welding, cold pressure welding, resistance welding and mechanical joining. Cold pressure welding is quite practical; joints have high strength and conductivity. Ultrasonic welding requires no heat, precleaning or flux; joints are made quickly between parts of different thicknesses, or of multiple thicknesses—and the weld can be made through many types of insulation.

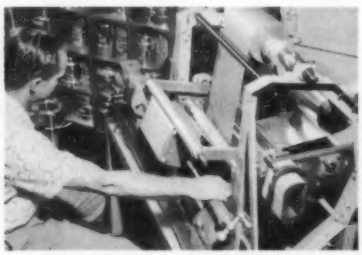
Where is the best application for aluminum strip windings? In power devices or electronic equipment, the economics of aluminum strip windings are indicated when customary wire sizes are 24 gage or larger. However, in many aircraft and missile applications, where weight is a critical factor, aluminum strip is a natural application regardless of size.

Here, at a glance, are the main areas of comparison:

PROPERTY	HARD-DRAWN COPPER WIRE	ALUMINUM STRIP No. 3 EC
Weight (lb/cu in.)	0.321	0.098
Specific gravity	8.89	2.70
Coefficient of linear expansion (/°C)	0.000017	0.000023
Thermal conductivity at 20°C $\left(\frac{\text{watts/sq in.}}{\text{in./°C}}\right)$	9.7	6.0
Electrical conductivity at 20°C, per cent IACS	97	61.0
Electrical resistance at 20°C (microhms/sq in./ft)	8.40	13.14
Temperature coefficient of electrical resistance at 20°C (/°C)	0.00381	0.00409
Modulus of elasticity	17 x 10^6	10 x 16^6

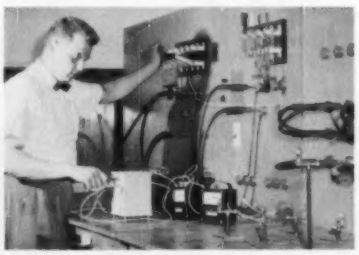
ALCOA Aluminum Electrical Windings will reduce your costs and improve your product. We'd like to prove it. Send your specifications to us and we will wind sample coils. Then make your own test.

ALUMINUM COMPANY OF AMERICA, 2262-M Alcoa Building, Pittsburgh 19, Pennsylvania.

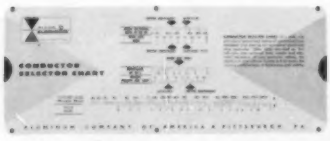


Interleaving sheet-type insulation with aluminum strip.

Specially designed equipment for winding smaller coils.



Preliminary testing of foil-wound transformer.

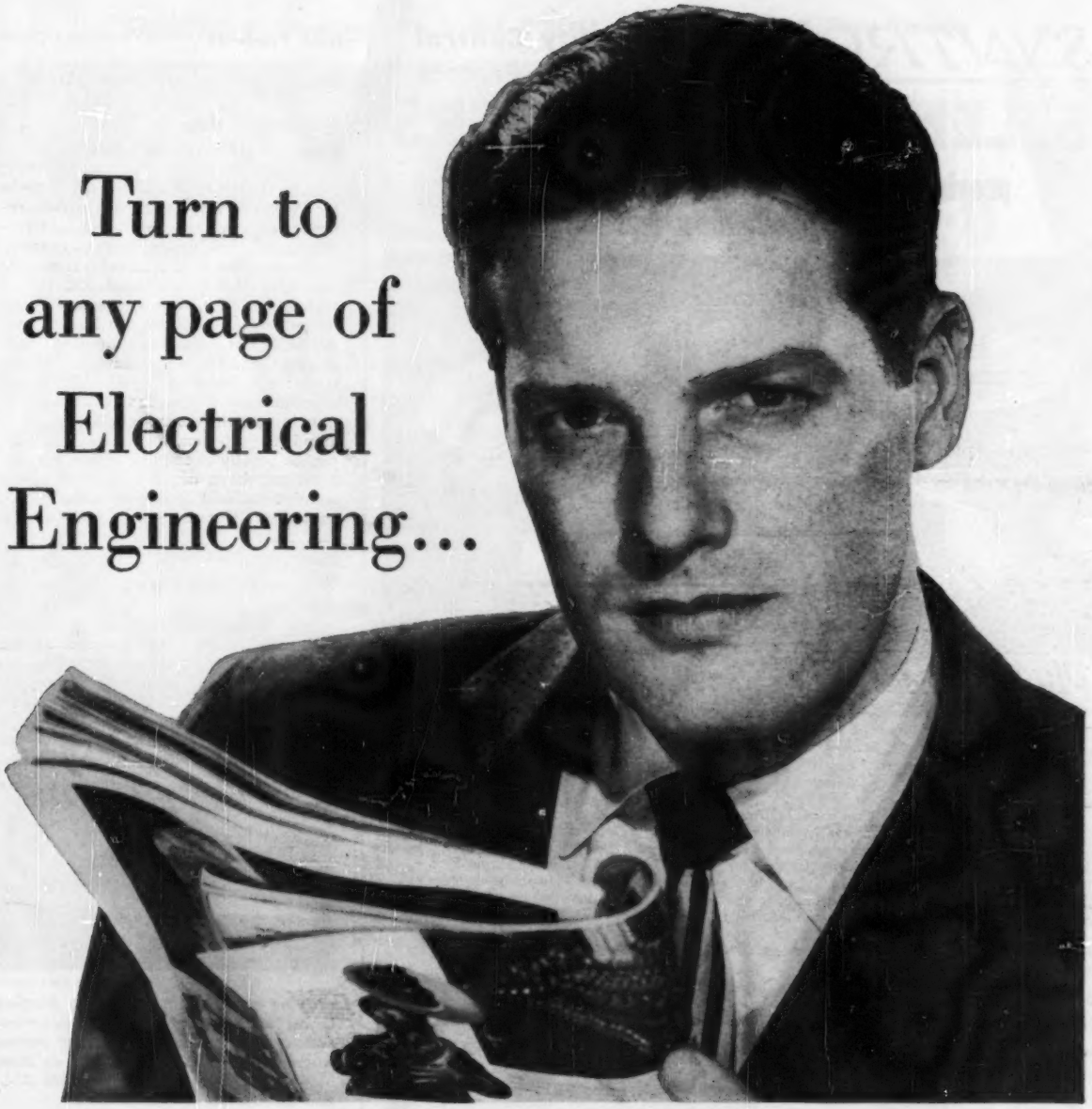


Send for Alcoa's new *Conductor Selector Chart*, a convenient slide rule for converting standard wire sizes to equivalent strip conductor.

ALCOA ALUMINUM
ALUMINUM COMPANY OF AMERICA

ALCOA THEATRE
Fine Entertainment
ALTERNATE MONDAY EVENINGS

Turn to any page of Electrical Engineering...



Closely related to EE's broad editorial coverage of news and factual information of the technological aspects of the industry—are the advertising messages appearing in its pages, monthly.

This advertising is designed to keep you informed—of product improvements and design, of the applications and use of apparatus and equipment, of the development of materials and components essential to your production.

And for those responsible for construction and installation – to point the way to lower costs and to short-cuts that help speed the job.

In short, advertising which appears in EE is contributing to your economic, technological and business progress. It will profit you to read it—with the same care and attention you give to the carefully compiled editorial pages of EE.

It will pay you to read advertising regularly in **ELECTRICAL ENGINEERING**

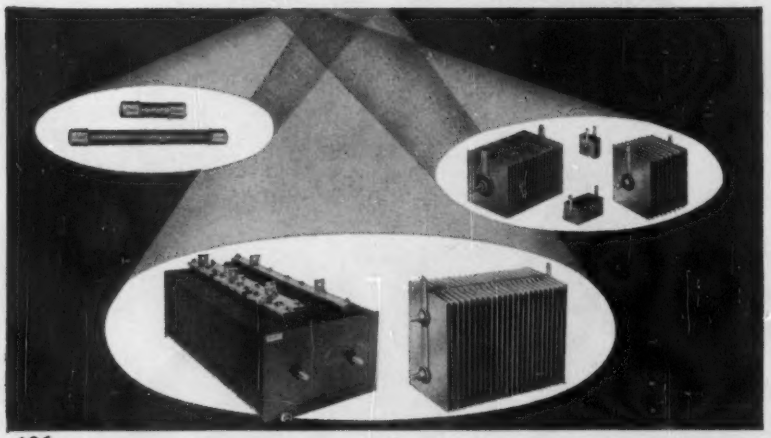
. . . the electrical engineers own magazine

SYNTRON

Quality Control
Vacuum Process

SELENIUM RECTIFIERS

provide quality performance,
dependability and longer life



Plus the widest range of cell sizes in the industry

For all your d-c power needs — SYNTRON Selenium Rectifier cells are manufactured by a unique vapor deposit vacuum process and quality control method to provide rectifiers of extreme uniformity, long life and stability.

Years of successful industrial and commercial application have proven their dependability and quality.

SYNTRON Selenium Rectifiers are noted for these outstanding characteristics that make them consistently out-perform and out-last similarly rated rectifiers—lowest voltage drop, lowest leakage current, lowest temperature rise, longest life, greater uniformity from cell to cell and greatest voltage ratings.

SYNTRON builds rectifier stacks for every application — from Industrial Power Stacks with 12" x 16" cells, largest in the industry, down to low current, high voltage hermetically sealed cartridge type stacks.

SYNTRON Selenium Rectifiers provide high efficiency, low maintenance and longer life to every application. E 658

Products of Proven Dependable Quality

Other SYNTRON Equipment
designed to increase production,
cut production costs, improve products

Vibrators (bins, hoppers, chutes)
Vibratory Feeders
Vibratory Screens
Shaker Conveyors
Vibratory Elevator Feeders
Weigh Feeders
Packers and Jolters
Hopper Feeders
Lapping Machines

Rectifiers (Silicon and Selenium)
a-c to d-c Selenium Rectifier Units
Electric Heating Panels
Electric Heating Elements
Sinuated Wires
Shaft Seals
Electric Hammers
Concrete Vibrators
Paper Joggers

Our representatives will be glad to work with you in selecting the proper equipment for your operation.

Call your nearest Syntron representative

For more information write for complete catalog . . Free

SYNTRON COMPANY
440 Lexington Avenue Homer City, Penna.

New Products

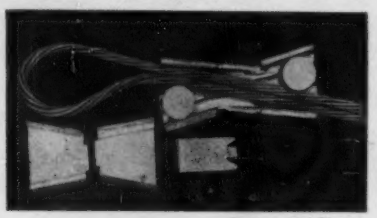
(Continued from page 38A)

Electronic Aid for Designing Transistor Circuits . . .

An electronic unit called the Transistor Circuit Synthesizer readily enables designers to check the performance of contemplated circuit designs without the need for a breadboard of soldered wires. This instrument has four independent panels, each a transistor stage, and a master metering panel. The device provides extreme flexibility to assemble common base, common emitter, and common collector circuit configurations. By combining two or more transistor panels through wires or plug-in shorting bars, circuits such as amplifiers, flip-flops, oscillators, and gates can be readily assembled. Either p-n-p or n-p-n transistors can be employed in the circuits. **National Electronics Laboratories, Inc., 1713 Kalorama Rd., N.W., Washington, D.C.**

Wire and Cable Clamp . . .

Requiring neither nuts, bolts, nor maintenance, the newly designed French self-locking clamp for wires and cables has been introduced. Included among the many advantages claimed by the manufacturer are a 30 to 50% reduction in labor and installation time as compared with older types of clamps, a series of tests



Courtesy Col-Pictures

showing that it holds without slipping beyond the breaking strength of guy wires and cables, and a performance record wherein it does the work of two or three old-style clamps. **Clamps, Inc., 5th Ave., and E. 10th St., Oakland, Calif.**

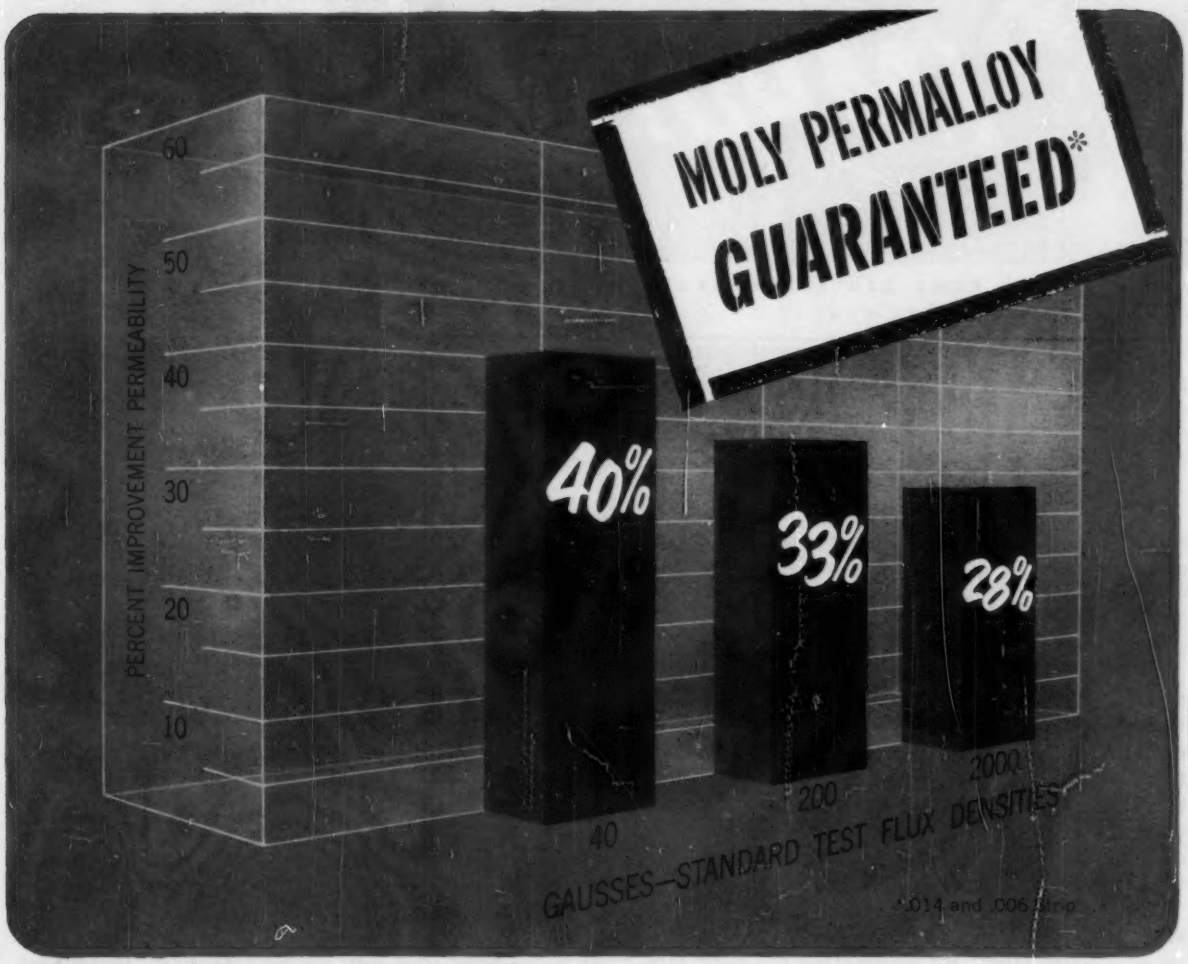
12½ Watt Rheostat . . .

A unit smaller than many 1- or 2-watt film or composition potentiometers, yet capable of 12½ watts dissipation at 40C is announced. This ceramic and metal unit is only ⅞ inch diameter and extends $1\frac{1}{16}$ inch behind the mounting panel. Capable of operation in high ambient temperatures, this unit lends itself to military and aircraft applications and opens new vistas in miniaturization. **Ohmite Manufacturing Company, 3698 Howard St., Skokie, Ill.**

High-Temperature Silicon Voltage Regulators . . .

Smaller, lightweight, more rugged voltage regulation circuits can now be

(Continued on page 48A)



GUARANTEED PERMEABILITY OF MOLY PERMALLOY...
at values higher than old average specifications

Molybdenum Permalloy nickel-iron strip is now available from Allegheny Ludlum with *guaranteed* permeability values. And the new guarantees are much higher than the old typical values. This exceptionally high quality means absolute uniformity for the user—new consistency and predictability for magnetic core performance.

Improved permeability of A-L Moly Permalloy is the result of Allegheny's program of production research on nickel-bearing electrical alloys. A similar improvement has been made in AL-4750 strip steel. Research is continuing on silicon steels including A-L's famous Silectron (grain oriented silicon steel), plus other magnetic alloys.

Another plus in dealing with Allegheny Ludlum is the operation of complete lamination fabrication and heat treatment facilities. A-L's years of experience in producing quality laminations result in practical know-how in solving problems common to core materials.

This working knowledge is available to all. Give us a call for prompt technical assistance on *any* problem involving electrical steels, laminations, or magnetic materials. Write for more information on A-L Moly Permalloy. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. EL-12.***

WSW 7273

ALLEGHENY LUDLUM
STEELMAKERS TO THE ELECTRICAL INDUSTRY

Export distribution, Electrical Materials: AIRCO INTERNATIONAL INC., NYC 17
Export distribution, Laminations: AD. AURIEMA, NYC 4

IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE CORPORATION, ROME, N. Y.
PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

POLITE POLICEMAN—Tomorrow's vehicle control system might parallel the electronic traffic control system of RCA's David Sarnoff Research Center. Transistorized detector units at the Center count passing cars on roads, measure their speed, and flash a polite warning saying "Slower Please" to drivers exceeding the posted speed limit.

AROUND THE MOON IN 208,000 WATTS—Data-seeking rockets and missiles present a new challenge to telemetry equipment. For example: with present equipment, Army missile experts estimate it would require *208,000* watts to relay a TV panorama of the moon back to earth. Needed: new concepts of conveying data through space.

INSTRUMENTATION CABLE BULLETIN—This 8-page illustrated bulletin discusses cable insulation and jacketing material and lists typical multi-conductor cable constructions available for use with telemetering equipment, data recording equipment, circuit control testing and electronic computers. Every *design engineer* working with electrical cable should have a copy! To obtain your *free* copy write to Rome Cable Corporation, Dept. RCD-400, 421 Ridge Street, Rome, New York.

WEE WIRING—Printed wiring boards, already small, might get even *smaller* soon! How? By eliminating the land area around the holes in the board. This is being done experimentally by some concerns by using plated-through hole techniques. Full-scale production of the new, smaller boards may not be far off.

UMBILICAL CORD . . . A cable fitted to the missile with a quick disconnect plug, through which missile equipment is controlled and tested while the vehicle is still attached to launching equipment. The umbilical cord is detached at or just prior to lift-off of the missile. (From Glossary of Guided Missile Terms put out by Air Force Missile Test Center, Cape Canaveral, Fla.)

CABLEMAN'S CORNER—Not too long ago, a new TV quiz program, entitled "Anybody Can Play," made its debut. No special knowledge was necessary—anyone could answer the questions.

Fine—for TV quiz programs. Dangerous—if applied to cable engineering and manufacture. For 100% reliability in multi-conductor cables—*you must call on a specialist!*

Why? Here are the reasons. If a cable is to be reliable, it must be: 1. Designed by an experienced cable engineer with a working knowledge of instrumentation problems. 2. Constructed of quality material—with the emphasis on solving the need—*and not on the price.* 3. Controlled and thoroughly tested during production. 4. Backed up by a reliable manufacturer who will stand firmly behind every cable produced.

Don't sacrifice reliability in cables for price. Call on a Cable Specialist. Our address is Rome Cable Corp., Dept. 429-D, 421 Ridge St., Rome, N. Y.

New Products

(Continued from page 46A)

designed through the use of silicon Zener voltage regulators in place of conventional gas tube regulator types. This series of 5-watt rated silicon voltage regulators enables the design engineer to specify any Zener voltage for exacting circuit requirements in the range from 24 to 160 volts. These regulators are designed to provide substantially lower dynamic resistance than comparable tube

types over a broad temperature range from —65C to +165C. The high Zener reference voltage and low dynamic resistance of these multiple junction units is caused by a series of matched and selected low voltage Zener diodes mounted and securely interconnected within an oil-filled housing designed to provide very low thermal resistance. **International Rectifier Corporation, 1521 E. Grand Ave., El Segundo, Calif.**

Rotating Mirror and Rotating Drum Cameras . . .

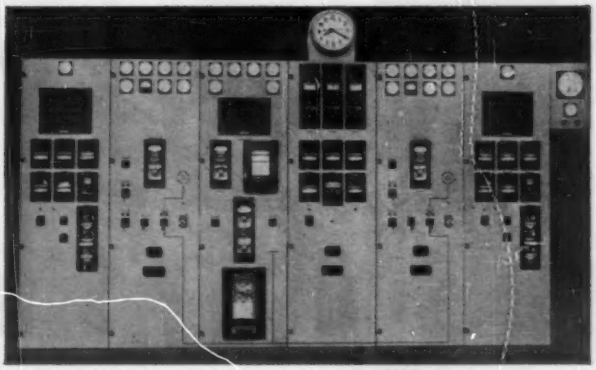
These laboratory standard instruments provide accurate and reliable photographic records of hypervelocity phenomena. The devices are valuable in studies of radiation, explosive compound development, solid fuel ignition, propulsion, ballistic combustion, chemical recombination, plasma tunnels, magneto-hydrodynamics, spark gap discharges, high-speed electromechanical units such as relays, and other transient events which emit or reflect light. The rotating mirror camera records position vs time relationships, sweeping the image from a hypersonic object source onto fast emulsion film strips. The rotating drum camera may be used with a densitometer to produce accurate data of hypervelocity phenomena. **Avco Manufacturing Corporation, Research and Advanced Development Division, 201 Lowell St., Wilmington, Mass.**

(Continued on page 52A)

in metal-clad switchgear...

Reliability

is born of many men's efforts



Indoor metal-clad power plant switchgear rated 4160 volts, 3 phase, 60 cycles supplied to a partially attended generating station.

It started with a directive—"Make it the best!" A creative team set out to implement this decision. Engineers, designers, production men, and marketing personnel—all took up the challenge. What was *then* good gave direction. They added their talents, their skill, their experience—up-to-date application requirements—designing, testing, redesigning until drawing board plans were translated to market place reality. Out came metal-clad switchgear preeminent in strength, simplicity, and performance. They *had* made it the best!

Type DST air circuit breaker—5 kv, 250 mva, 1200 amps.

From simple feeder circuits to complex generating station protection—when you specify Federal Pacific metal-clad switchgear, you specify reliability. Proof is yours for the asking. Write Federal Pacific Electric Company, Newark, New Jersey for Catalog 3-440—sixty-four pages of the latest in metal-clad switchgear information.

FEDERAL FPE PACIFIC

The Best in Electrical Distribution and Control Equipment

MOLDED CASE CIRCUIT BREAKERS

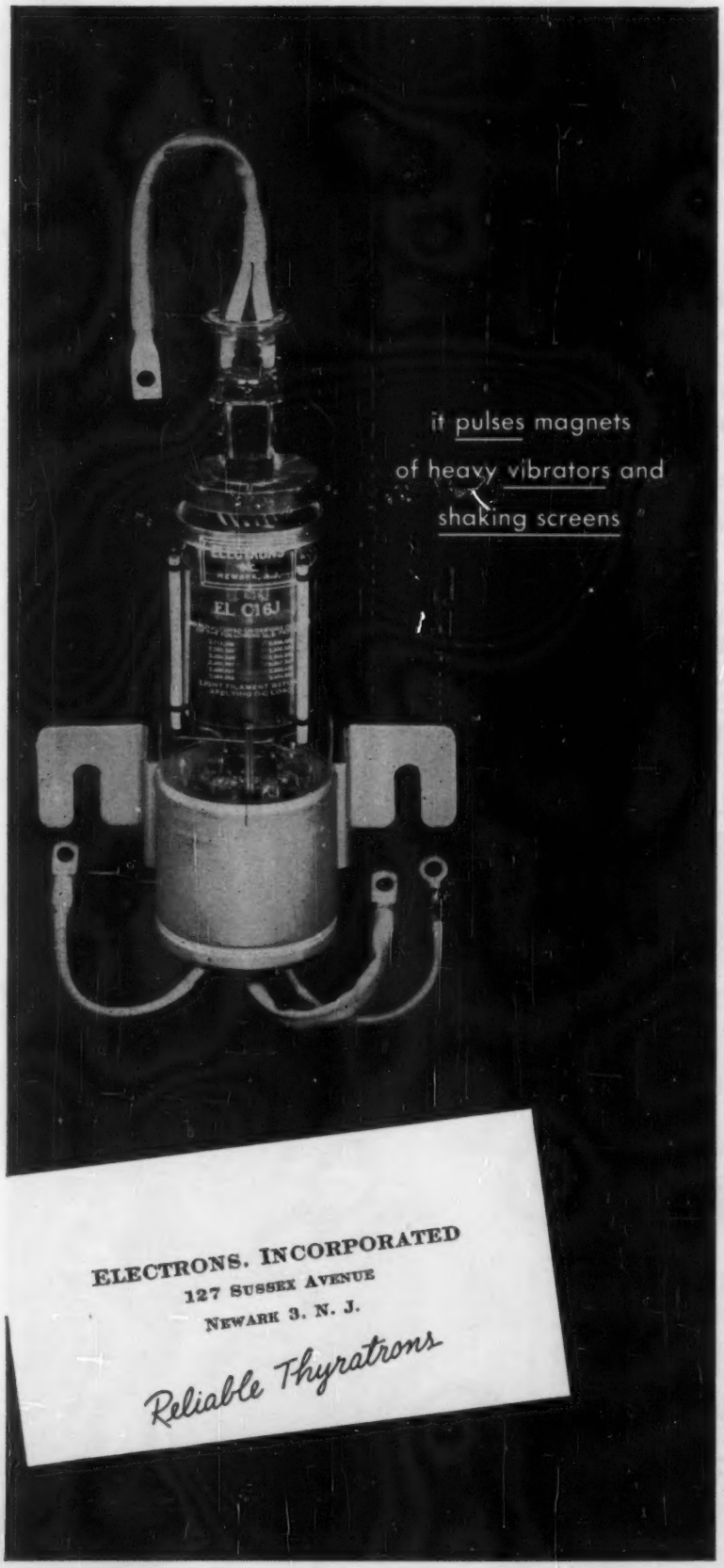
YOU GET "EXTRA QUALITY —AT NO EXTRA COST" in Industry's Most Complete and Diversified Line

From the smallest EQ* circuit breakers for lighting circuit protection, through the ET*'s and exclusive CORDONS®—with 100,000 amp interrupting capacities—to the many special-purpose breakers, such as the 400 cycle, 1000 v selective trip breaker designed for Navy use, I-T-E molded case circuit breakers constitute industry's most complete line.

Not only is the I-T-E line the most complete and most diversified, but I-T-E's famed "extra quality—at no extra cost" is built into every product which bears the I-T-E label. And you can depend on the nation-wide network of I-T-E distributors and field engineers to give you second-to-none service. I-T-E Circuit Breaker Co., Small Air Circuit Breaker Division, 19th and Hamilton Streets, Philadelphia 30, Pa.

*I-T-E trademark

I-T-E CIRCUIT BREAKER COMPANY

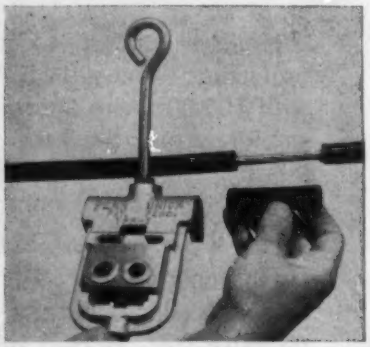


New Products

(Continued from page 48A)

Insulation Stripper . . .

Now, hard-to-remove insulations such as linear polyethylene can be quickly and easily stripped without nicking or scratching the conductor. The Penn-Peeler is designed to remove a 2½ inch length of



polyethylene, polyvinyl chloride, rubber, or neoprene insulations from $\frac{5}{64}$ths to $\frac{12}{64}$ths wall on conductors ranging from No. 2 stranded to 4/0 steel-reinforced aluminum cable. **Penn-Union Electric Corporation, 315 State St., Erie, Pa.**

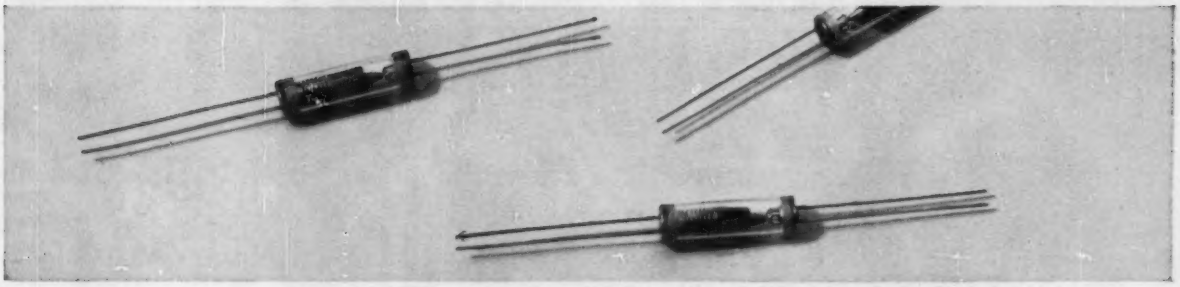
Two Protective Relays . . .

Two classes of protective relays, Type *CDG* Inverse and Type *VAR 11* are intended for use by utility and industrial companies in controlling the distribution of electricity. The Type *CDG* is an induction disk relay with inverse time characteristics and adjustments for time and current pick-up. Chief features of the Type *CDG* relays are simplicity of construction and ease of accessibility for adjustment. In current settings, standard ranges of 0.5-2 amperes, 1.5-6 amperes, and 4-12 amperes are available, each range being adjustable in seven steps. The *VAR 11*, which is designed for the immediate reclosing of electrically operated breakers, has the special features of antipumping, self reset, and lockout if fault persists. The standard voltage ratings are 48 volts, 125 volts, 250 volts d-c, and 115 volts and 230 volts a-c. Its current burdens are 115 volts a-c, 0.011 amperes, 125 volts d-c, 0.009 amperes, and 48 volts d-c, 0.035 amperes. **Federal Pacific Electric Co., 50 Paris St., Newark, N. J.**

Streamlined Silicon Power Rectifiers . . .

These power rectifiers feature a new low silhouette and are streamlined to save space. Current ratings range from 20 to 200 amperes and the peak inverse voltage range is from 50 to 300 volts for flush- or stud-base mounting in either positive or negative base polarity. **Sarkes Tarzian, Inc., Rectifier Division, 415 N. College Ave., Bloomington, Ind.**

HUGHES THERMAL RELAYS



FOR RELIABILITY

IN GUIDED MISSILES

Hughes now makes commercially available a completely reliable single action switch. Used in the Falcon, field proven as a reliable missile, this Hughes relay is engineered to meet the most exacting of requirements.

With unusual speed of action, firing signal triggers the release of constrained contact... contact closes upon fixed contact point... switch circuit becomes permanently closed.

In a typical application, 3.0 volts DC applied to a firing circuit of 1.2 ohms fire within 0.3 seconds.

For additional information please write: Hughes Products Marketing Department, International Airport Station, Los Angeles 45, California.

SPECIFICATIONS

MECHANICAL—Body Size: Maximum diameter 0.252"; length .920". Total weight: Less than 0.1 oz.

ELECTRICAL—**Before Firing:** Insulation resistance is greater than 200 megohms. Minimum breakdown voltage 600 volts.

Firing: 2 volts minimum required. Actual voltage dependent upon closing time desired.

After Firing: Circuit resistance less than 0.3 ohm.

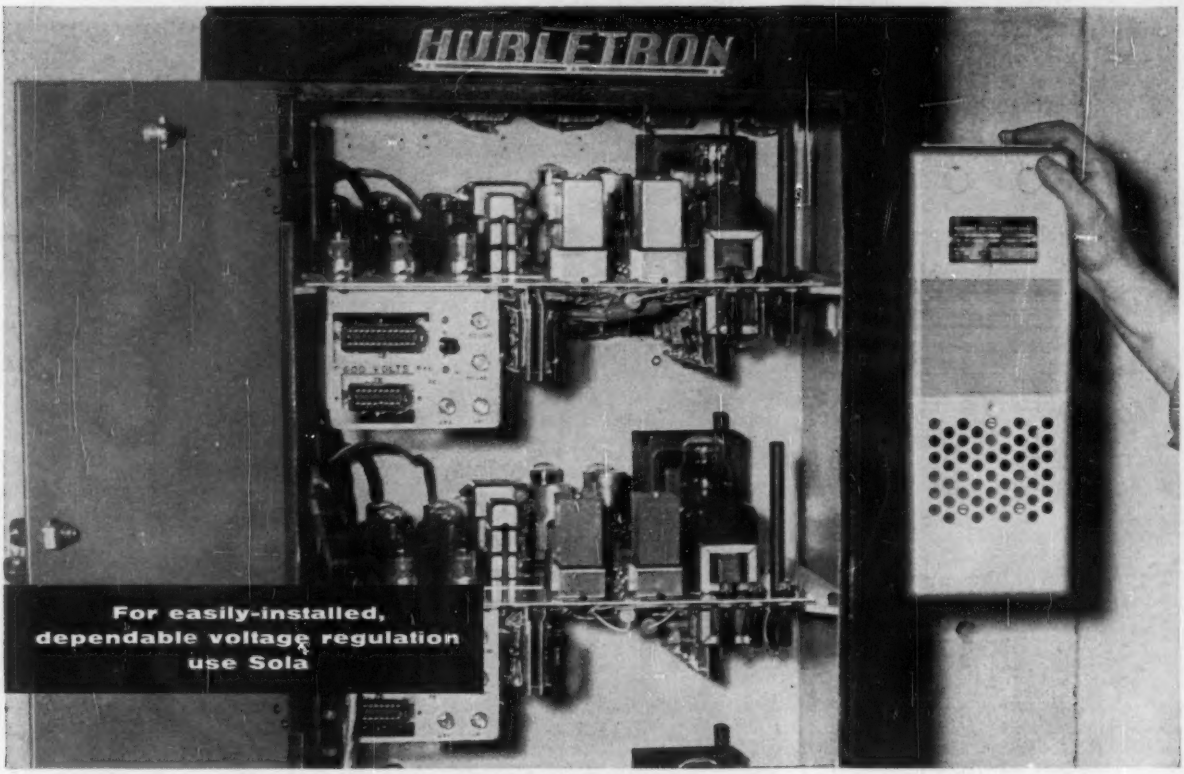
ALTITUDE—Any.

OPERATING TEMPERATURE: −55°C to +125°C.

Creating a new world with ELECTRONICS **HUGHES PRODUCTS**

SEMICONDUCTOR DEVICES • STORAGE AND MICROWAVE TUBES • CRYSTAL FILTERS
OSCILLOSCOPES • RELAYS • SWITCHES • INDUSTRIAL CONTROL SYSTEMS

© 1958, Hughes Aircraft Company



FIVE constant voltage transformer types answer most stabilizing needs

1 **Standard Sola Constant Voltage Transformers** can be built into your equipment, or added as an accessory. Either way it's simple, and economical of space and money to do it with a Sola. For example, Electric Eye Equipment Company uses it as a standard accessory on their Hurletron, automatic, proportional printing register control. The transformer is pictured above, mounted to the right of the control cabinet.

The Sola Constant Voltage Transformer stabilizes output voltage within ±1% regardless of input voltage variations up to ±15%. Response is within 1.5 cycles. It is a static-magnetic regulator . . . has no tubes or moving parts; requires no manual adjustments, or maintenance.

2 **Harmonic-Free*:** Output voltage wave has less than 3% total rms harmonic content . . . other features identical with standard type . . . automatic, continuous regulation . . . for rectifiers and other loads sensitive to harmonics . . . low external field.

3 **Plate-Filament*:** Regulation is ±3% with line input between 100-130v . . . plate and filament windings are combined on a single, compact core for chassis mounting . . . good isolation of input and output circuits . . . automatic, static-magnetic regulation.

4 **Filament*:** Regulation ±1% with input voltage fluctuations up to ±15% . . . 6.3v output for large numbers of electron tubes . . . current-limiting action minimizes cold inrush currents, also protects against damage from load faults . . . 75-80% efficiency.

5 **Adjustable, Harmonic-Free:** Provides output adjustable from 0-130 volts, ac, . . . regulates within ±1% with less than 3% total rms harmonic content . . . portable for lab or shop use . . . or mounts on rack.

*Available from stock or custom-designed.

For complete data write for Bulletin 5L-CV-170

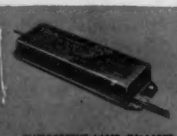
Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill., Bishop 2-1414 • Offices in principal cities • In Canada, Sola Electric (Canada) Ltd., 24 Canmotor Ave., Toronto 18, Ont.

SOLA

CONSTANT VOLTAGE TRANSFORMERS

REGULATED DC POWER SUPPLIES

MERCURY LAMP TRANSFORMERS


FLUORESCENT LAMP BALLASTS

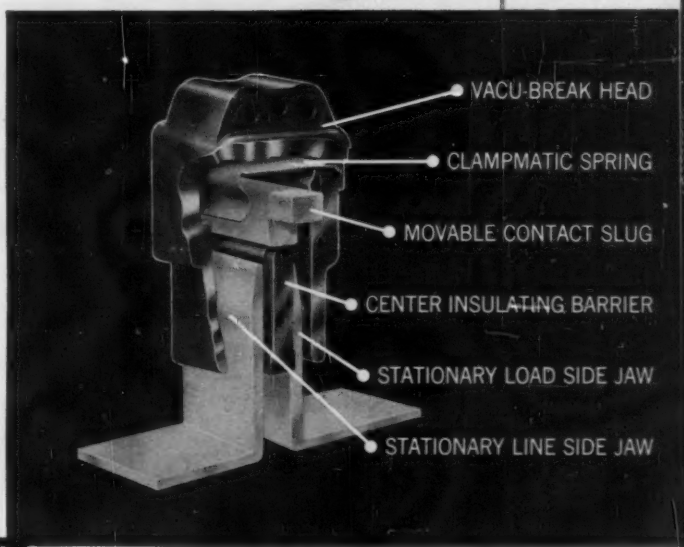
A DIVISION OF BASIC PRODUCTS CORPORATION

FOR SAFETY'S SAKE BUY VACU-BREAK

There's a big difference in safety switches—a difference between maximum safety and halfway safety—low maintenance and excessive maintenance. These differences are readily apparent when you look at the design and operation of the BullDog Vacu-Break Clampmatic* Safety Switch.

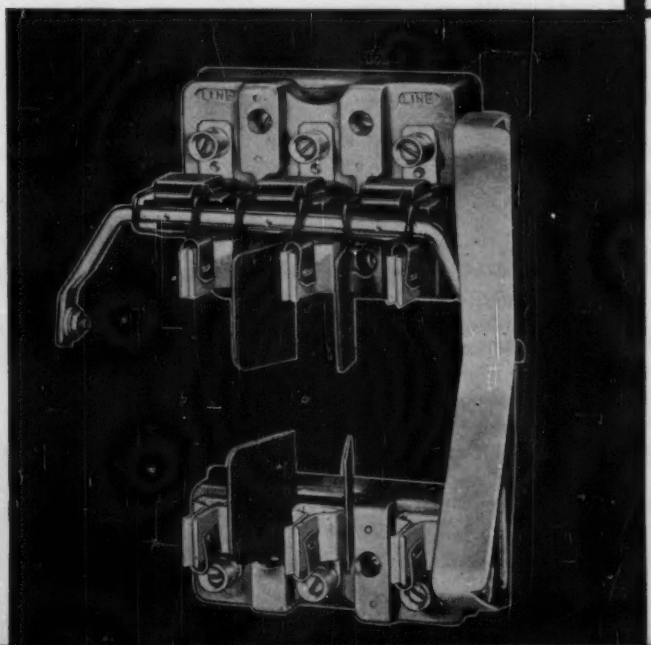
THE VACU-BREAK: Contacts are housed inside compact arc chambers which have very little air space. When contacts are "broken" under load, arcs can't build up because of the lack of oxygen. Pitting and burning of the contacts are reduced to the absolute minimum. Maintenance is virtually eliminated.

POSITIVE SWITCHING: For positive safety, the Vacu-Break switching mechanism does not rely on tricky toggles or springs to trigger the disconnect operation. The operating handle is directly connected to the contact heads by means of a sturdy *metal* rod. Push the handle "OFF" and the switch *is off!*



Vacu-Break heads are connected directly to the switch handle. No toggles or triggers . . . no tricky springs. No danger of switching failure, either. One of several exclusive BullDog Vacu-Break features that set the performance standards for the industry.

Close-up of Vacu-Break head shows movable contact slug inside the compact, oxygen-limiting arc chamber. Clampmatic spring assembly assures bolt-tight contact, speeds "break". This combination guarantees positive, safe operation, long switch life.



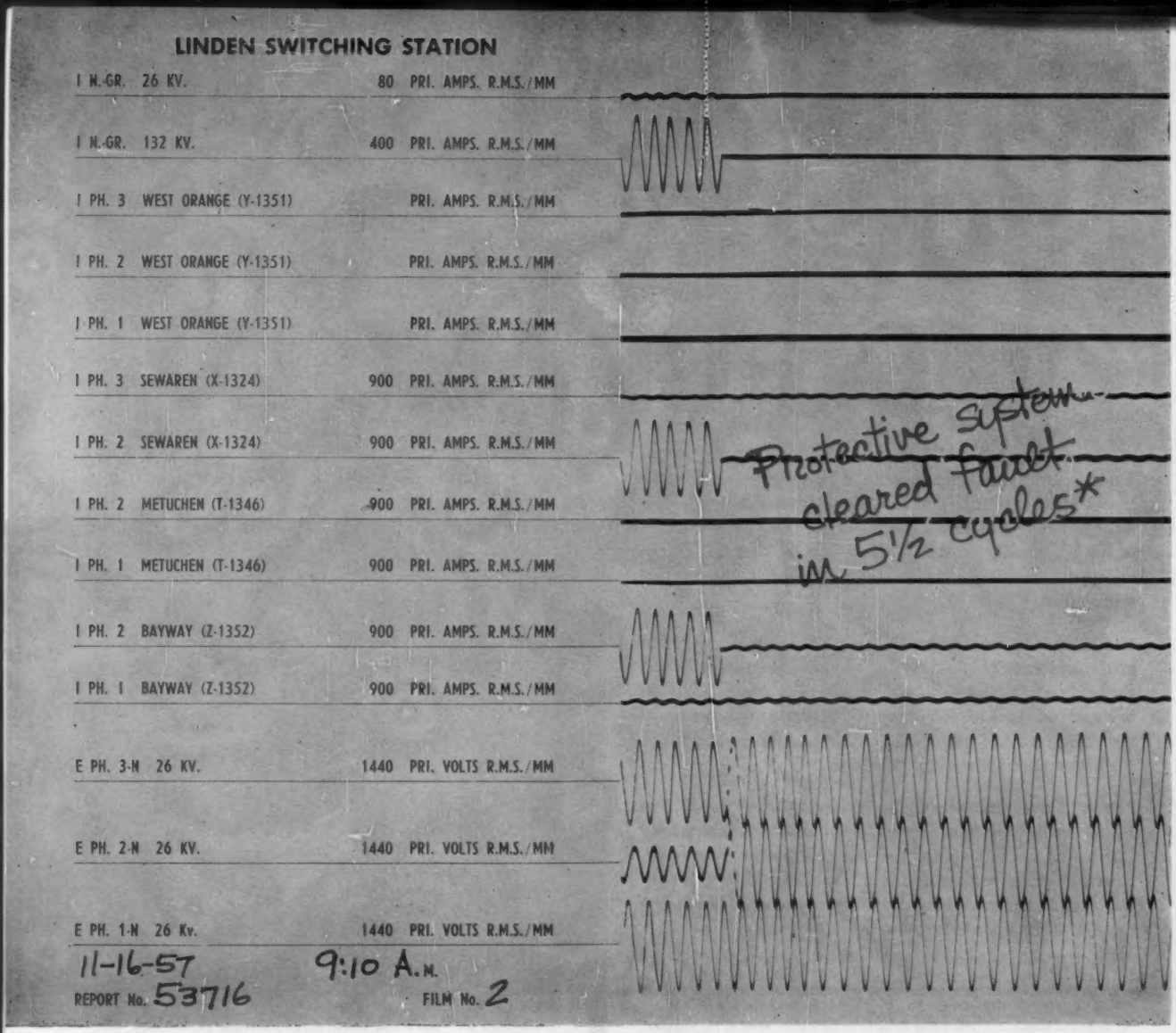
WITHSTAND 100,000 AMP FAULT CURRENT: Vacu-Break Clampmatic switches equipped with current-limiting type Amp-Traps** were subjected to 100,000 amp short circuit current. *The switches were undamaged.*

Play it safe! Compare, recommend, *buy* . . . BullDog Vacu-Break Clampmatic Safety Switches. They cost no more than other switches . . . yet give you the maximum in safety and performance. © BEPCO

**Vacu-Break and Clampmatic are registered trademarks of the BullDog Electric Products Company.*
***Amp-Trap is a registered trademark of the Chase-Shawmut Company.*

BULLDOG

BullDog Electric Products Company, Division of I-T-E Circuit Breaker Company, Detroit 32, Michigan. *BullDog Export Division:* 13 East 40th Street, New York 16, New York. *In Canada:* BullDog Electric Products Co. (Canada) Ltd., 80 Clayson Rd., Toronto 15, Ont.


LINDEN SWITCHING STATION
I N.-GR. 26 KV. 80 PRI. AMPS. R.M.S./MM
I N.-GR. 132 KV. 400 PRI. AMPS. R.M.S./MM
I PH. 3 WEST ORANGE (Y-1351) PRI. AMPS. R.M.S./MM
I PH. 2 WEST ORANGE (Y-1351) PRI. AMPS. R.M.S./MM
I PH. 1 WEST ORANGE (Y-1351) PRI. AMPS. R.M.S./MM
I PH. 3 SEWAREN (X-1324) 900 PRI. AMPS. R.M.S./MM
I PH. 2 SEWAREN (X-1324) 900 PRI. AMPS. R.M.S./MM
I PH. 2 METUCHEN (T-1346) 900 PRI. AMPS. R.M.S./MM
I PH. 1 METUCHEN (T-1346) 900 PRI. AMPS. R.M.S./MM
I PH. 2 BAYWAY (Z-1352) 900 PRI. AMPS. R.M.S./MM
I PH. 1 BAYWAY (Z-1352) 900 PRI. AMPS. R.M.S./MM
E PH. 3-N 26 KV. 1440 PRI. VOLTS R.M.S./MM
E PH. 2-N 26 KV. 1440 PRI. VOLTS R.M.S./MM
E PH. 1-N 26 Kv. 1440 PRI. VOLTS R.M.S./MM
Protective system cleared fault in 5½ cycles*
11-16-57 9:10 A.M.
REPORT No. 53716 FILM No. 2

A pothead failed . . .

RECORD ENDS GUESSWORK AS TO OPERATION OF PROTECTIVE SYSTEM

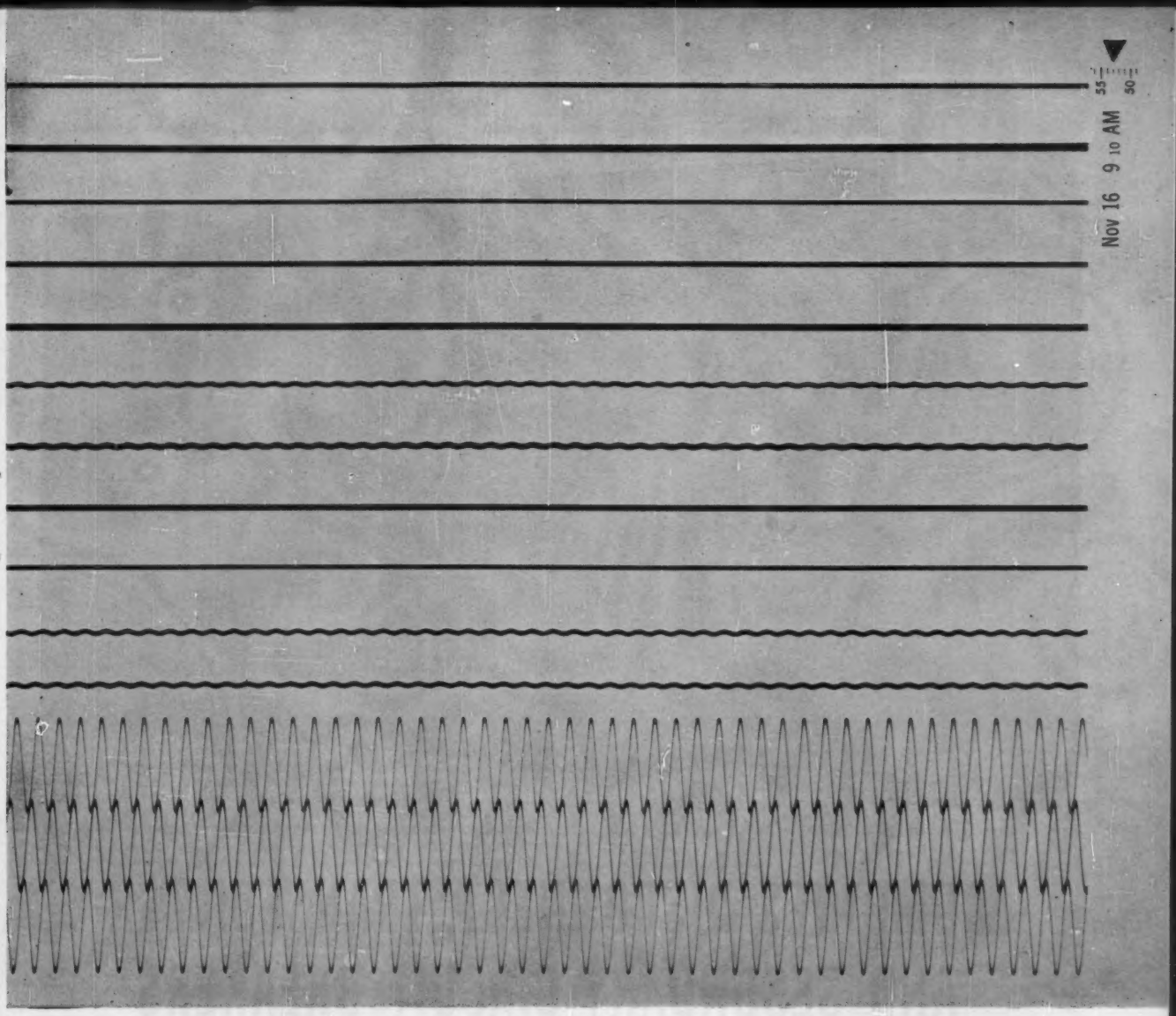
This is the record made by a Hamilton RS-9 Automatic Oscillograph when a pothead failed at the Linden Generating Station of the Public Service Electric and Gas Co., Newark, New Jersey.

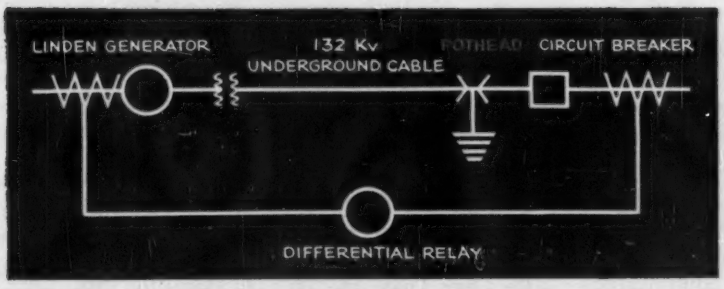
Analysis of the record shows that failure was from phase 2 to ground; and that the fault was located at a pothead on the underground cable carrying 132 KV, connecting the 450,000 KW capacity power plant to the switching station.

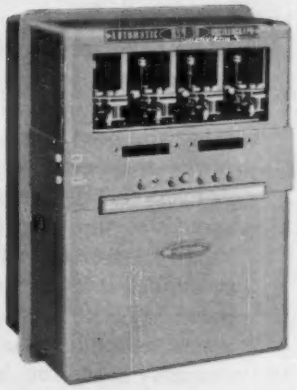
Most important, the record shows that the breakers of the high speed differential protective system cleared the fault within 5½ cycles—providing complete assurance that the protective system operated as designed, saving possible outage, damage and loss of revenue.

The Public Service Electric and Gas Co. has several Hamilton RS-9 Automatic Oscillographs standing by, monitoring their system. Within 2 milliseconds after a fault occurs, an instrument is automatically at work, making a permanent record of the transient wave forms. The time and date of the fault are recorded. Then, after the fault has cleared, the oscillograph stops and automatically resets itself to record the next fault.

The RS-9 provides an accurate record of the sequence of operation of a protective system of relays and breakers, ending time-consuming, inconclusive guesswork. It can provide assurance that the protective system is operating properly...that generators, large power transformers and transmission line facil-







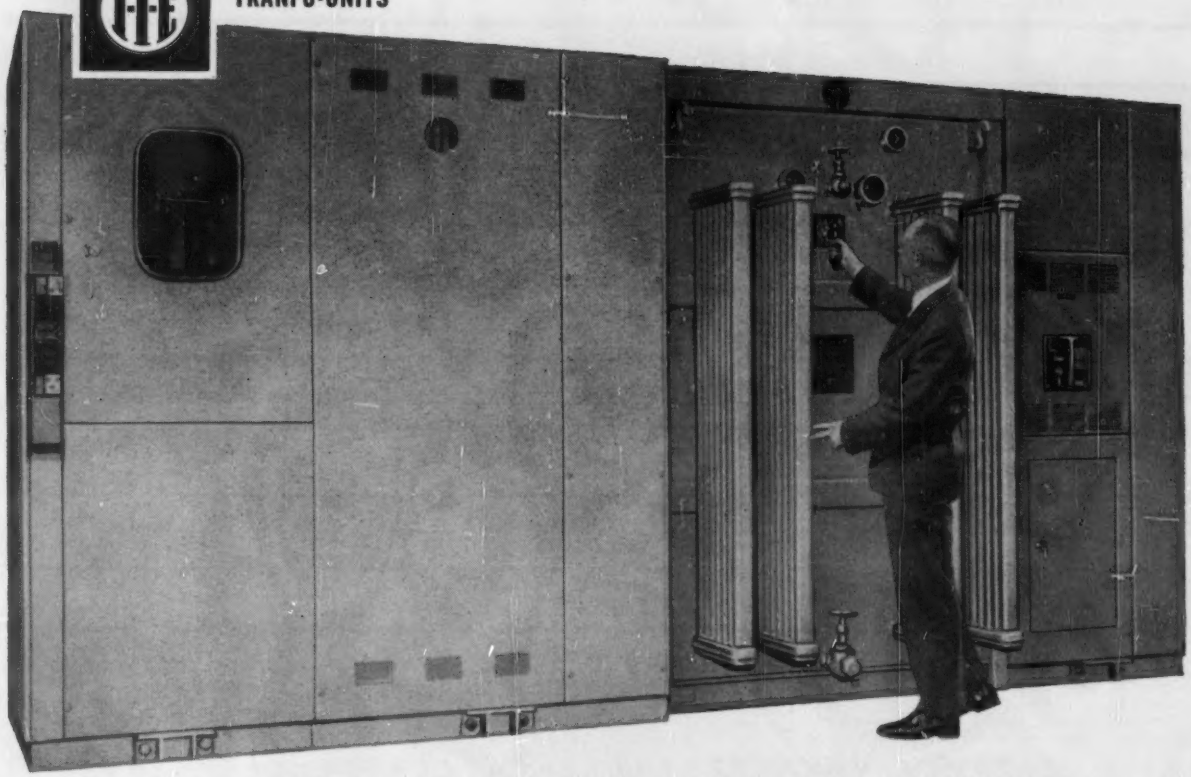
ities are fully protected. And it can warn of the malfunctioning of protective equipment before damage is caused.

There are two models of the Hamilton RS-9 Automatic Oscillograph. The RS-9 Fourteen has 14 channels for recording information. The RS-9 Thirty has 32 channels, providing a system with the extra capacity required in future years as the system becomes more complex.

For complete information about the RS-9 Automatic Oscillograph, write: Hamilton Watch Company, Hathaway Instrument Division, Denver, Colorado.

HAMILTON WATCH COMPANY
HATHAWAY INSTRUMENT DIVISION
5800 East Jewell Avenue Denver 22, Colorado

TRANFO-UNITS



Neat, compact and completely self-contained—a practical, economical way to bring in your electric power at low cost higher voltage.

COMBINES DISCONNECT, TRANSFORMER AND SECONDARY CIRCUIT BREAKERS

More compact than a substation . . . better looking than combinations of loose equipment, yet no more costly . . . here is everything you need in many applications to buy power at economical high voltages.

Every I-T-E Tranfo-Unit is completely assembled and wired at the factory, and no live parts are exposed to contact by personnel. It is normally shipped as a single package. But heavier units are split for easier handling. There is no complicated assembly at the site. You simply position it, connect it, and it's ready for operation. There is nothing else to buy—no additional engineering required.

For supermarkets, schools, office buildings, factories and many other power uses, the I-T-E Tranfo-Unit means new safety, new ease of installation, new improved appearance for power entrance equipment. Available in ratings from 45 through 3000 kva, primaries through 14.4 kv, secondaries through 600 v. For literature, write I-T-E Circuit Breaker Company, Transformer & Rectifier Division, 19th & Hamilton Sts., Philadelphia 30, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ont.

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA, PENNSYLVANIA

AIEE SPECIAL PUBLICATIONS

To meet a specialized need, or where it has become advantageous to collate a number of papers on a subject in one pamphlet, a series of special publications has been established. Prices quoted are (M) for AIEE members, and (N) for non-members.

		PRICE M	N
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S104	Application of Incremental Heat Rates for Economic Dispatch of Power (7/58)	3.00	3.00
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S6	Bibliography on Automatic Stations, 1930-1941 (12/42)	.25	.50
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S45	Power Supply for Resistance Welding Machines (4/52)	1.00	1.00
T101	Proceedings of the Computers in Control Systems Conference (5/58)	3.50	3.50
T70	Proceedings of the Eastern Joint Computer Conference (4/55)	3.00	3.00
T92	Proceedings of the Eastern Joint Computer Conference (5/57)	3.00	3.00
T85	Proceedings of the Western Joint Computer Conference	3.00	3.00
T93	Rectifiers in Industry (5/57)	4.00	4.00
S53	Review of Input and Output Equipment Used in Computing Systems (3/53)	4.00	4.00
S95	Second Symposium on Polyethylene Wire and Cable Insulation (10/58)	1.00	1.00
S42	Sources of Electrical Energy (1/51)	.75	1.50
S36	Symposium on Electrical Properties of Semiconductors and the Transistor (1/50)	.25	.50
S66	Symposium on Higher Distribution Voltage for Metropolitan Area (9/54)	2.00	2.00
S82	Symposium on Research and Education (2/56)	.80	1.60
S56	Symposium on the Use of Aluminum for Insulated Conductors (11/53)	1.50	1.50
S12	Telemetering, Supervisory Control, and Associated Circuits (9/48)	1.00	2.00
S61	Thermal Evaluation of Insulating Materials (6/54)	1.50	1.50
S63	The 2nd Feedback Control Systems Conference (4/54)	3.50	3.50
T96	Third Biennial AIEE Conference on Electric Heating (4/57)	3.50	3.50
T76	Western Joint Computer Conference (3/55)	3.00	3.00

*An AIEE Conference Report, consisting of the full texts of the papers and discussions presented at a special AIEE technical conference on the subject.

Also available is the following publication, issued by EJC (Engineers Joint Council) of which AIEE is a member:

S13	Engineering Profession in Transition (1947)	.50	1.00

DETACH

This is an order from: (Please print)

Name .....

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☐S50, ☐S51, ☐S53, ☐S56, ☐S57, ☐S57d, ☐S58, ☐S60,
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☐T72, ☐S74, ☐T76, ☐S79, ☐S82, ☐S84, ☐T85, ☐S87,
☐T88, ☐T89, ☐S90, ☐T91, ☐T92, ☐T93, ☐S94, ☐S95,
☐T96, ☐T97, ☐T98, ☐T99, ☐S100, ☐T101, ☐S102, ☐S104,
☐T105, ☐T106.

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33 WEST 39TH STREET
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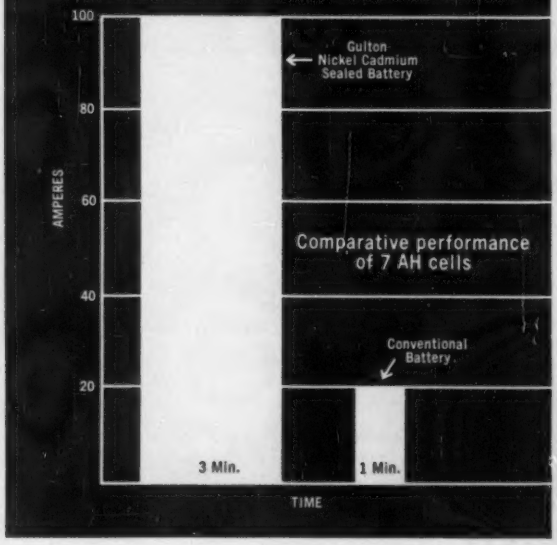
City ..... Zone .... State .....

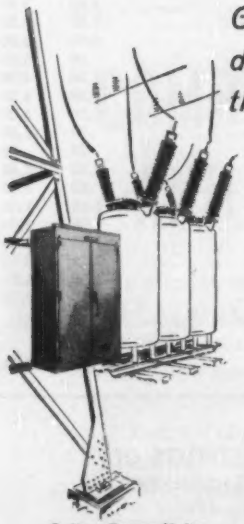
(CONTENTS—PRINTED MATTER)

POSTMASTER: This parcel may be opened for Postal Inspection if necessary. Return postage guaranteed.

"VO" SEALED BATTERIES

give you highest peak current, small space, and no maintenance





Gulton Power Units
A completely automatic, unattended, maintenance-free source of DC power for operating circuit breakers, relays, controls, lighting, motor starters, etc. Ask for Bulletin No. GPU.

Gulton "VO" nickel cadmium batteries deliver 20 times the punch, take 1/20 the space, don't need maintenance!

Gulton "VO" *sealed* alkaline batteries, with *patented sintered plate construction*, give you every advantage over conventional units—including end economy.

First, you get peaks up to 20 times rated capacity in a fraction of the space required by other units. Second, "VO" batteries are non-gassing, never lose active material. That means no maintenance, simple low-cost installation anywhere.

Other advantages: extremely long life, indefinite storage in any state, dependable performance in any service or climate. Coupled with a compact Gulton automatic charger, these batteries will give top service, unattended, year after year.

For more information, write Alkaline Battery Division, Gulton Industries, Inc., Metuchen, N. J.

ALKALINE BATTERY DIVISION
Gulton Industries, Inc.
Metuchen, New Jersey

NOW—

You Can Keep Your Copies of ELECTRICAL ENGINEERING in Orderly Fashion and Good Condition

Practical attractive binders that hold the issues of ELECTRICAL ENGINEERING for one year are now available. Your copies may be easily and quickly inserted, and can be removed readily, if necessary.

Binders have stiff covers of heavy quality dark blue imitation leather, round corners, and are embossed on the cover and backbone with the title, the Institute's emblem, and the words—Jan.-June; July-Dec.

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Order Department

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

New cup-washer selenium rectifiers

reduced size and weight, superior performance

General Electric's new cup-washer design makes possible increased contact area between cells — resulting in lower contact resistance and improved surge ratings. These new Vac-u-Sel* selenium rectifiers withstand ambients up to 130°C, yet you pay no premium for high-temperature operation. Cells are rated from 2 to 15 amperes and can be stacked for higher currents.

Special spring washers on both stack ends create a tighter assembly, both initially and throughout stack life. Size and weight are reduced to save design space and give you a lighter unit with superior performance. Improved paint seal reduces the chance for contamination. New terminals provide holes for either screw or solder connections. The increased surge rating makes these rectifiers particularly well suited for welding-equipment applications.

Advances like this (and others coming soon) illustrate the increasing usefulness of selenium components. For more information on industry's most complete line of selenium rectifiers, contact your G-E Semiconductor Products Sales Office, or write Section S18128, General Electric Company, Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

VAC-U-SEL rectifiers are made by General Electric's spherical evaporation process, through which a pure, more even deposition of selenium over the entire cell surface is obtained. This results in longer life—even at high operating ambients and better-than-normal rated current. Performance can be reliably predicted from unit to unit.

*Registered Trade Mark of General Electric Company.

GENERAL ELECTRIC

FREE!...

to qualified *Designers, Engineers, Metallurgists*

TECH DATA BOOK

HIGH-CONDUCTIVITY HIGH-WORKABILITY COPPER

To men who design and select materials for electrical equipment, the properties of copper are becoming increasingly important. Greater operating capacities, new fabricating techniques, new standards of accuracy and performance all require better materials . . . better, purer metals.

"Technical Survey of OFHC® Brand Copper"—first complete compilation of technical data on high-conductivity, oxygen-free OFHC Copper—points up significant effects of purity on the electrical and mechanical characteristics of copper. Topics include:

- nature of OFHC Copper
- physical characteristics when unalloyed
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- effects of impurities and alloying elements
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Supplementing the text are more than one hundred tables, charts, graphs, and photographs.

Published by AMAX as a service to industry, this handsome, 122-page volume is available to you *without cost or obligation.* For your free copy, simply fill in the attached form and mail it to us. Supply is limited, so write today!

Product Development Department

AMERICAN METAL CLIMAX, Inc.

61 Broadway, New York 6, New York

AMAX

Yes! I would like to own "Technical Survey of OFHC Brand Copper." I understand that the book is free and there is absolutely no obligation.

NAME.....

POSITION.....

COMPANY.....

ADDRESS.....

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(Offer good only as long as supply lasts.)

Industrial Notes...

Vermilya Brown Co. New York, N. Y. . .

One-hundred foot high outlets are a record-breaking feature of an air conditioning installation recently completed for Riverside Church, New York, N.Y. The installation is part of a modernization program and an eight-story addition to the church. Because of the unusual height at which the conditioned air enters the nave, the project is practically pioneering in air conditioning engineering. Such outlets usually are only about 12 feet above floor level. The unusual height resulted from efforts to save the church a sizable expense by utilizing the ducts of a natural-air circulation system installed about 1928. Vermilya Brown Company, Inc., 100 E. 42nd St., New York 17, N.Y.

Autonetics Downey, Calif. . .

Spinning for a time-span that would permit nine one-way trips to Mars, this long-lasting bearing, like those in guidance systems for eventual use in space travel, continues to break endurance records in North American Aviation's Autonetics Division. Six years' rotation of this gas-lubricated bearing has proved it nearly friction-free and reliable enough for the rigorous demands of space travel. Estimated time for a trip to Mars is about 8 months. This bearing and many more advanced ones, designed, developed, and tested by Autonetics under contracts to the U.S. Air Force and Navy, replace conventional ball bearings but differ from them in being able to operate forever, because gas, as a lubricant, does not wear out. Autonetics Division, North American Aviation, Inc., 9150 E. Imperial Hwy., Downey, Calif.

S & C Electric Co. Chicago, Ill. . .

A distribution equipment mobile demonstrator has been sent out to the field by S & C Electric Company, 4435 Ravenswood Ave., Chicago 40, Ill., to show actual physical operating of disconnects, cutouts, Loadbuster, fuse links, and handling tools. The demonstrator carries its own collapsible cross arm pole, an aluminum frame which takes the equipment 12 feet above the ground. When shown to electric utilities, the demonstrator will explain the ways of achieving maximum safety of distribution equipment. When the tail gate of this orthodox-appearing station wagon opens, a telescoping rack rides out, a section of it rotates through 90 degrees, and supporting feet drop to the pavement. Then a worm-and-gear, operated by a battery-powered motor, sends the cross arm with the demonstration equipment up to a height of 12 feet, where the devices can be operated at a realistic height.

Gardner-Denver Co. Quincy, Ill. . .

A new machine that automatically wires sections of electronic computers has been put into operation by the Hughes Aircraft Company, Santa Monica, Calif. A product of the Gardner-Denver Company, Wire-Wrap Division, Front St., Quincy, Ill., the $40,000 Wire-Wrap machine with electronic controls is being used by Hughes for automatically wiring an airborne communications system known as Lost Chord for the Wright Air Development Center. The special unit can be modified for other applications. The automatic unit is capable of wiring terminals in a 10 by 10 inch area section of a 20 by 20 inch panel and can be operated by keyboard or punched tape.

ITT Laboratories Palo Alto, Calif. . .

The name of Federal Telecommunication Laboratories, a Division of International Telephone and Telegraph Corporation has been changed to ITT Laboratories, a Division of International Telephone and Telegraph Corporation. The address is 937 Commercial St., Palo Alto, Calif.

Howard Industries, Inc. Racine, Wis. . .

Another motor line has been acquired by Howard Industries, Inc., completing the purchase of Induction Motors from Westinghouse Electric Corporation, Lima, Ohio. The equipment will be moved to the Racine plant. Late in 1957, the company purchased the Universal Motor Division of Westinghouse Electric Corporation. The equipment from this division was also moved to the Racine plant. In March 1958, the physical assets, business, and name of the Loyd Scruggs Company, Festus, Mo., were purchased. Howard's main office is at 208 S. LaSalle St., Chicago, Ill., with its principal plant in Racine, Wis.

(Continued on page 67A)

How does this square with your own experience?

(A CHECKLIST FOR EE READERS)

Advertising in EE is designed, primarily, to direct you to sources of supply: apparatus, materials, components, equipment.

But there are additional benefits to be gained directly from information which companies include in their technical advertising.

For example: in replying to a recent survey by a leading marketing magazine*—22 of the nation's top engineers cited some 26 areas in which information they read in advertising was of specific service.

Their list is in the column at the right. Check it yourself—and see if it doesn't square with your own experience!

*Tide magazine

CHECK AND COMPARE . . .

(with your own experience) these benefits leading engineers said they obtained from advertising:

- ☐ reduced maintenance costs
- ☐ improved quality
- ☐ cost reduction
- ☐ simplified manufacture
- ☐ increased capacity
- ☐ improved materials
- ☐ improved appearance
- ☐ simplified processes
- ☐ improvements in design components
- ☐ higher speeds and feeds
- ☐ aided research
- ☐ reduced spoilage
- ☐ cut construction costs
- ☐ improved finishes
- ☐ improved automatic features
- ☐ better control
- ☐ eliminated shut downs
- ☐ reduced assembly steps
- ☐ improved safety
- ☐ power economy
- ☐ economy in first cost
- ☐ improved plastics
- ☐ lower cost per hour of use
- ☐ improved employe morale
- ☐ utilized smaller space
- ☐ obtained personnel

It will pay you to read advertising regularly in **ELECTRICAL ENGINEERING**

. . . the electrical engineers own magazine

THE INDUSTRY'S FIRST *single-vent*

THE HUBBARD EHD

THE HUBBARD EHD Cutout is one of the first products to be designed, developed and perfected in the new, completely integrated Hubbard Electrical Research Laboratory. It is here that the single-vent, small-bore operation in the extra heavy duty range—long acclaimed as the most desirable but thought impossible—has now been achieved and thoroughly and conclusively tested.

THIS EMBLEM —symbolic of the Hubbard EHD, the industry's first Single-Vent, Small-Bore Cutout—is your assurance of *positive and safe* protection against all fault currents from a minor overload to the maximum rating of the EHD Cutout.

SINGLE VENT
EHD
SMALL BORE

HUBBARD EHD
Open Dropout Cutout
Rated—100 amperes continuous current
10,000 amperes at 5.2 kv and 7.8 kv
8,000 amperes at 15 kv

small-bore extra heavy duty cutout

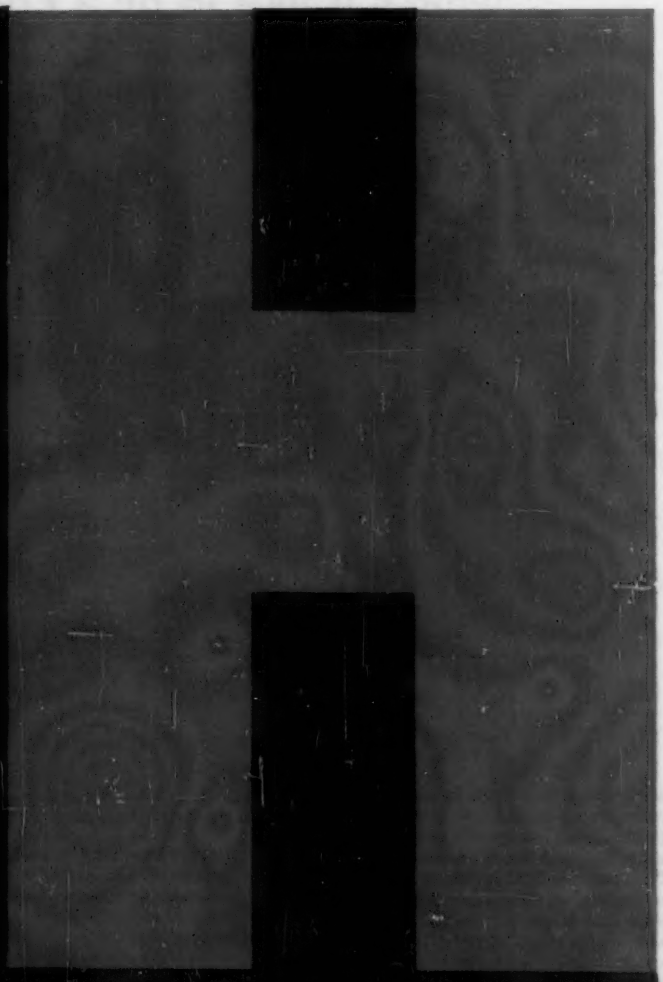
WHAT DOES SINGLE-VENT SMALL-BORE MEAN TO YOU?

The confinement offered by a single-vent, small-bore fuse tube is well recognized as the most efficient condition for fault current interruption. As applied to the Hubbard EHD Cut-out it offers:

POSITIVE PROTECTION throughout the *full range* of fault currents from small overloads to high short circuit currents —without "null operating points." This safe and positive fault current interruption prevents unnecessary service outages.

SAFE OPERATION—the single exhaust envelope, discharged in a small confined cone, eliminates double gas envelopes and rifle-velocity expendable parts. The ingenious thrust-absorbing recoil design controls the single-vent jet action. Safety to personnel and equipment is assured at all times.

Ask your Hubbard representative to show you complete test results, including ultra high speed movies which stop the action of an EHD Cutout clearing an 8000 amp fault current.



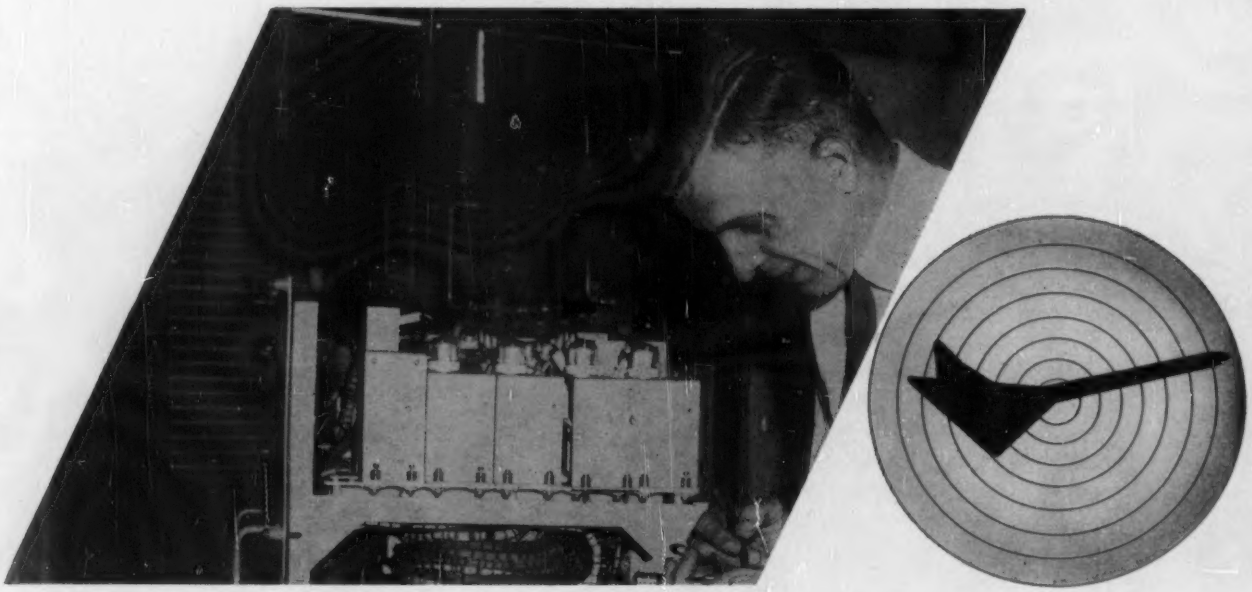
HUBBARD

AND COMPANY · 200 South Michigan Avenue · Chicago 4, Illinois

Manufactured in Canada by N. Slater Company, Limited • Hamilton, Ontario

TEST EQUIPMENT ENGINEER John W. Lloyd tells why his work in the B-70 weapons system at IBM Owego affords him the creative engineering career he always wanted.

what's it like to be a creative engineer at IBM?



Assignments now open include...

MAGNETICS ENGINEER to design and analyze magnetic core circuitry for use in advanced digital computers. Assignment entails application of these circuits to logical connectives and systems. **Qualifications:** B.S. or Advanced Degree in E.E. or Engineering Physics and 2 to 5 years' experience with magnetic circuitry. Must be familiar with fundamentals of non-linear magnetics and have strong interest in logical circuit application of magnetics.

PACKAGING ENGINEER to undertake development and design of packaging techniques and mechanical design of electronic equipment; to investigate temperature effects on packaging; to offer design support to computer, radar, and inertial development groups; to analyze present and proposed packaging design and recommend improvements.
Qualifications: B.S. in E.E. or M.E. and experience or advanced knowledge in latest electronic packaging techniques.

RADAR ENGINEER to analyze ultimate limits of present techniques and develop new concepts of providing topographical sensors for advanced airborne and space systems; to design airborne radar pulse, microwave and deflection circuitry; to analyze doppler radar systems in order to determine theoretical accuracy and performance limitations.
Qualifications: B.S. or Advanced Degree in E.E. and 3 to 5 years' experience in radar systems development, including display equipment and circuits, control consoles, and doppler or search radar design.

CIRCUIT ENGINEER to undertake advanced circuit design based on transistor-diode logic for digital systems; to review new circuits for application in digital control systems; to define basic techniques for improving performance characteristics; to participate in advanced analytical studies associated with application of transistor circuitry to pulse and digital systems.
Qualifications: B.S. or Advanced Degree in E.E. and 2 years' experience with pulse circuitry, transistor circuit design or digital techniques.

GROUND SUPPORT EQUIPMENT ENGINEER to assist in planning complete ground support equipment, including flight line, shop and depot equipment, for an advanced airborne weapons system. Must be experienced in development of test equipment for automatic checkout of complex weapons systems, including computers, radar, and inertial equipment.
Qualifications: B.S. or Advanced Degree in E.E. or related fields and 3 years' experience in developing ground support equipment.

A wide variety of exciting career opportunities awaits creative engineers and scientists at IBM Owego in applying IBM's computer technology to integrated B-70 bombing-navigation systems. Test Equipment Engineer John W. Lloyd, describing his assignments at IBM Owego, says: "Test equipment engineering is particularly stimulating when it's part of a project as new and important as the B-70, sometimes described as a 'huge flying computer.' Right now I'm coordinating the design of engineering support equipment for an advanced digital airborne computer, part of the B-70's bombing-navigation and missile guidance system. There's a minimum of routine. In order to design test equipment you must know—or learn—about the equipment to be tested; among these are radar, servo systems, digital and analog computers, and inertial guidance. I see my professional growth assured as IBM continues to develop computers for airborne applications."

IBM is a recognized leader in the computer systems field. Its products are used for both military and commercial work. You will find ground-floor opportunities for professional advancement at IBM Owego, where the "small-team" approach assures quick recognition of individual merit. Company benefits set standards for industry today, and salaries are commensurate with your abilities and experience.

Ideally situated in rolling New York State countryside, Owego, in the Binghamton Triple City area, provides an excellent environment for gracious, relaxed family living. Owego's proximity to both New York City and the Finger Lakes offers a pleasant variety of recreational opportunities.

CAREER OPPORTUNITIES IN THESE AREAS . . .

Airborne digital & analog computers
Ground support equipment
Inertial guidance & missile systems
Information & network theory
Magnetic engineering
Maintainability engineering
Optics
Radar electronics & systems
Servo-mechanism design & analysis
Theoretical design & analysis
Transistor circuits

There are other openings in related fields to broaden your skills and knowledge.

Qualifications: B.S., M.S. or Ph.D. in Electrical or Mechanical Engineering, Physics, Mathematics—and proven ability to assume a high degree of technical responsibility in your sphere of interest.

FOR DETAILS, just write, outlining background and interests, to:
Mr. P. E. Strohm, Dept. 550Z
International Business Machines Corp.
Owego, New York

IBM®
MILITARY PRODUCTS DIVISION

Industrial Notes

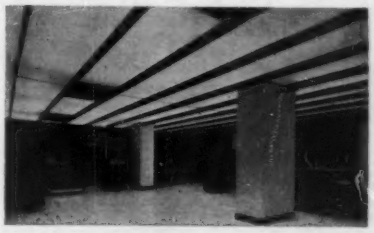
(Continued from page 62A)

General Atomic San Diego, Calif. . .

The entire staff of General Atomic Division of General Dynamics Corporation is now located at the John Jay Hopkins Laboratory for Pure and Applied Science. The new facility is located on Torrey Pines Mesa, north of the junction of Highway 101 and Miramar Rd., overlooking the Sorrento Valley. The street address is 10955 John Jay Hopkins Drive; however, the mailing address remains the same as before, P. O. Box 608, San Diego 12, Calif. The new telephone number is GLencourt 9-2310.

Contrex Co. Chelsea, Mass. . .

Soundsheet provides both sound control and quality illumination for International Business Machines Corporation's (IBM) new showroom in Chicago, Ill. The light diffusing and acoustical media used in the system is corrugated Soundsheet, manufactured by Contrex Company, Chelsea 50, Mass. Corrugated Soundsheet, an acoustical vinyl laminate of 0.013-inch nominal thickness, has a noise reduction coefficient of 0.70. Light transmission is



48%. The showroom, built inside a large area, has single-pane glass from floor to ceiling on two walls, and a raised metal floor. Thus, there is no noise absorption from the floor and two of the walls. Soundsheet provides softly diffused quality illumination, plus the high degree of acoustical correction needed in the IBM showroom. Maintained footcandle level is in excess of 100.

Taylor Fibre Co. Norristown, Pa. . .

This company has extended the size range of its rolled laminated-plastic tubes by reducing the minimum inside diameter to 0.050 inch. Its maximum ID (inside diameter) for rolled tubing is 36 inches. The company's previous minmimum ID for rolled laminated tubing was 0.125 inch. At present the sizes below 0.125 inch ID are furnished in Grade *XX* laminated plastic. This is a paper base, phenolic resin grade which has good electrical, mechanical, and physical properties.

(Continued on page 72A)

FREED MAGNETIC AMPLIFIERS *and* SATURABLE TRANSFORMERS FOR IMMEDIATE DELIVERY

FAST RESPONSE MAGNETIC AMPLIFIERS
2∿ response — Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	AC or DC signal voltage req'd for full output.	
MAF-1	60	13	110	1.0	—
MAF-6	400	5	57.5	1.2	0.4
	400	10	57.5	1.6	0.6
MAF-7	400	15	57.5	2.5	1.0

SINGLE ENDED MAGNETIC AMPLIFIERS

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Sig. req'd for full outp. MA-DC	Total res contr. wdg. K Ω	Load res. ohms
MAG-1	60	4.5	3.0	1.2	3800
MAG-2	60	20	1.8	1.3	700
MAG-4	60	400	9.0	10.0	25
MAG-5	60	575	6.0	10.0	25

PUSH-PULL MAGNETIC AMPLIFIERS
Phase reversible

Cat. No.	Supply Freq. C.P.S.	Power Out. Watts	Volt. Out. V. AC	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. KΩ
MAP-1	60	5	115	1.2	1.2
MAP-2	60	15	115	1.6	2.4
MAP-3	60	50	115	2.0	0.5
MAP-3-A	60	50	115	7.0	2.9
MAP-4	60	175	115	8.0	6.0
MAP-7	400	15	115	0.6	2.8
MAP-8	400	50	110	1.75	0.6

SATURABLE TRANSFORMERS
Phase reversible

Cat. No.	Supply Freq. in C.P.S.	Power Out. Watts	Volt. Out. V. AC	Sig. req'd for full outp. MA-DC	Total res. contr. wdg. KΩ
MAS-1	60	15	115	6.0	27
MAS-2	400	6	115	4.0	10
MAS-5	400	2.7	26	4.0	3.2
MAS-6	400	30	115	4.0	8.0
MAS-7	400	40	115	5.5	8.0

All units designed for 115V-AC operation

Write for detailed listing, or special requirements, and copies of complete Transformer and Laboratory Test Instrument Catalogs.

FREED TRANSFORMER CO., INC.
1700 Weirfield Street
Brooklyn (Ridgewood) 27, New York

Trade Literature...

"Improving Business" Data Booklet . . .

A booklet containing charts, checklists, and other useful management information is now available. Entitled "Improving Business," the pamphlet discusses such factors as optimum yearly sales per employee, productivity per square foot for different industries, and how sales volume affects sales dollar breakdown. For a free copy write to the **E. Norman Kagan Company, Empire State Building, New York 1, N. Y.**

Metal Film Precision Resistors Bulletin . . .

New metal film precision resistors are described in a brochure recently released which details the increased resistance range offered by these units in spite of their reduced size. It describes new shapes and the lower temperature coefficient of resistance now established as standard for these units. For complete information, request a copy of Bulletin *155* from the **Ohmite Manufacturing Company, 3696 W. Howard St., Skokie, Ill.**

Silicone Rubber Data Bulletins . . .

Data bulletins describing compound properties of three formulations of Silicol silicon rubber are now available. These bulletins are the first of other similar bulletins to be published covering all of the company's stock compounds in both natural and synthetic rubber. Silicol rubbers covered in data bulletins *C-4019-S*, *C-4020-S* and *C-4021-S* are recommended for general molding purposes such as for seals, gaskets, and special shapes for industrial use, including applications in aircraft and missile manufacturing. Copies may be obtained by writing to the company. **Colonial Rubber Company, Ravenna, Ohio.**

Office of Improvement Booklet . . .

An analysis of the areas of office operation and suggestions for making improvements are outlined in a new booklet entitled "100 Ways To Improve Efficiency—Save Money in Your Office." The booklet considers the various office expenses which the operation of a business entails and points out proper planning procedures which will effect improvements. The booklet may be obtained free of charge from **Manpower, Inc., 810 N. Plankington Ave., Milwaukee 3, Wis.**

Low Voltage Switching System Brochure

An 18-page full-color brochure which describes low voltage switching systems has been published and is now available to architects, contractors, electricians, and others interested in installing low voltage systems. Featured in the brochure are sections devoted to designing a system, architects' specifications, planning the installation, installing a touch-plate system, trouble shooting and installation, and basic components of a system. The brochure is free of charge. **Touch-Plate Mfg. Corp., P. O. Box 1970, Long Beach, Calif.**

Guide to Office Copying Machines . . .

An illustrated booklet, especially prepared as a factual guide in the selection of office copying machines, has been published by Copease Corporation. Titled "The Truth About Office Copying Machines," the booklet analyzes the principal reasons for the growing use of copying equipment in modern business offices, and points out the advantages and disadvantages, if any, of the various copying machines on the market. Copies of the new booklet and additional information on Copease photo-copy machines may be obtained from **Copease Corporation, 425 Park Avenue, New York, N.Y.**

Knitted Mesh Booklet . . .

"Knitted Mesh, Its Properties and Uses," is available upon request from **Metal Textile Corporation, Division of General Cable Corporation, 643 E. First Ave., Roselle, N. J.**

Electromagnetic Relays Conference Papers . . .

The papers presented at the 6th National Conference on Electro Magnetic Relays at Oklahoma State University, Stillwater, Okla., have been published. The booklet contains 33 papers by 42 authors. Timely subjects are discussed, such as shock testing microminiature relays, vacuum relays, reliability problems, and contact resistance. Papers representing England, Canada, and Japan are also presented. Copies of the booklet may be obtained free of charge from the **Advertising Department, Potter & Brumfield, Inc., Princeton, Ind.**

"Hydrocarbon Vapor Adsorption" . . .

Bulletin *SC-1047*, "Hydrocarbon Vapor Adsorption", available without cost, describes how Selas Vape-Sorbers provide clean dry air and gas for hospitals, pharmaceutical manufacturers, chemical manufacturers, food processors, petroleum refineries, steel plants, metal fabricators, instrument manufacturers, industrial gas manufacturers, bottling plants, ammonia plants, and users of pneumatic instruments and pneumatic tools. **Selas Corporation of America, Dept. 19, Dresher, Pa.**

(Continued on page 75A)

Professional Engineering Directory

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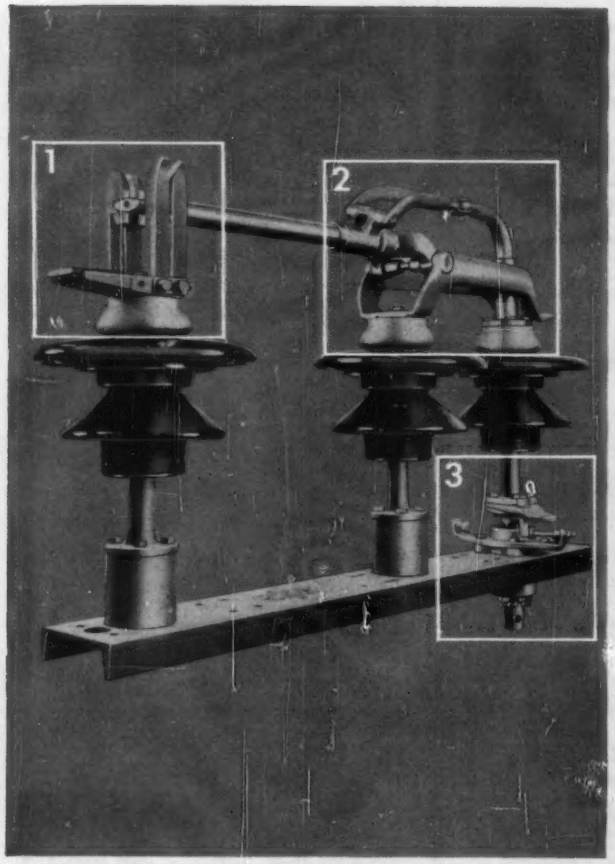
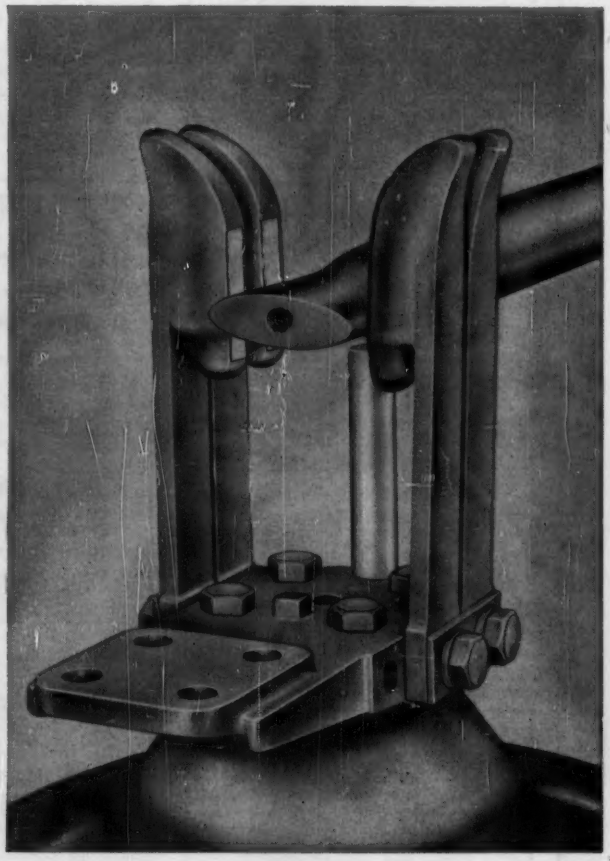


Look for rounded contours on all parts and liberal spacing between parts having relative motion. R&IE switches, designed this way, can be actuated under severe icing conditions with surprising ease. Other switches, with complicated or closely packed mechanisms, are generally handicapped by relatively thin ice coatings, locked by heavier ones.



1 Look for a heavy copper jaw with silver-to-copper contacts. Thus constructed, R&IE switches show no evidence of overheating when tested well above their short-time current ratings. R&IE avoids the use of thin stamped jaws, which lack thermal capacity, often burn or erode under overload or fault currents . . . requiring more frequent maintenance.

Compare R&IE switches, point by point, with others. Discover the extra assurances of better performance, which you get at no extra cost. Available in ratings from 7.5 to 345 kv and from 400 to 6000 amp. For complete information, ask your nearby I-T-E sales office for a copy of Bulletin 1342-A. Or write R&IE Equipment Division, Greensburg, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ont.

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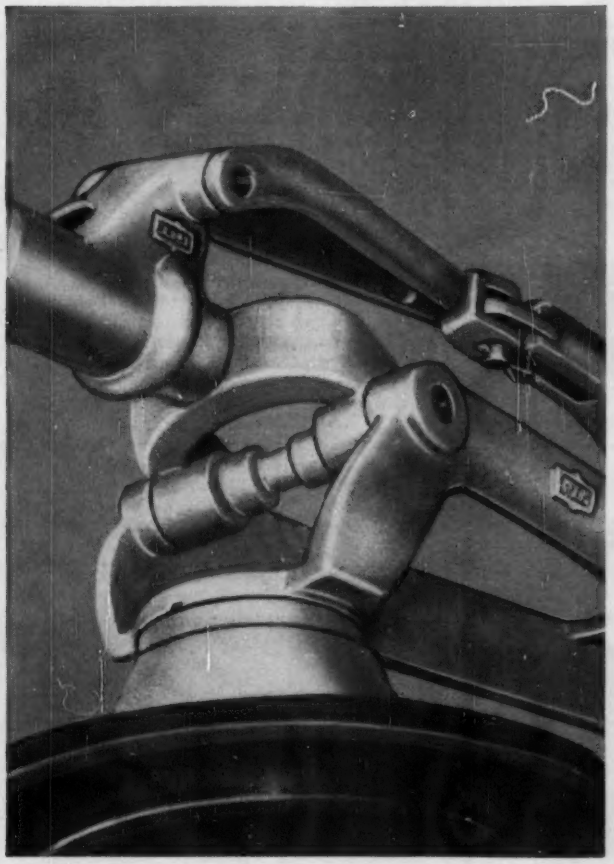

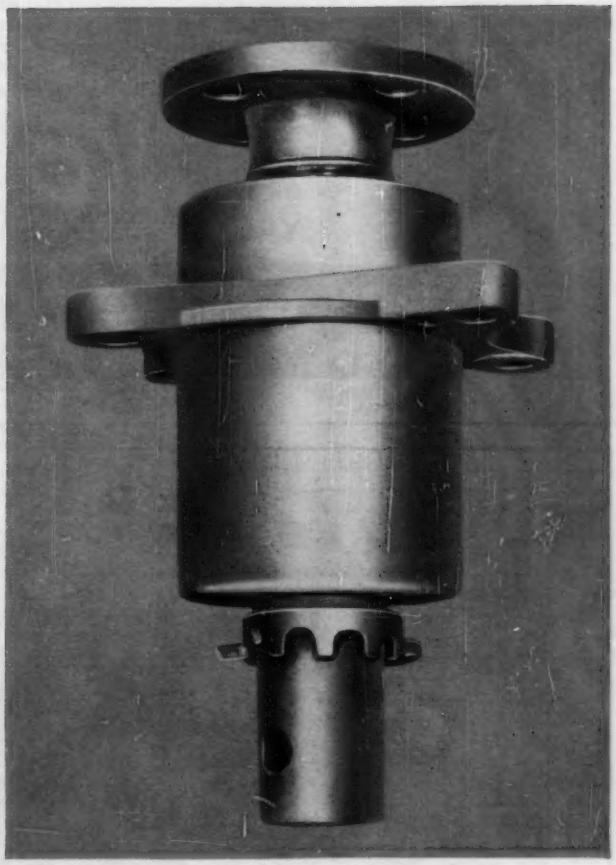

2 Look for sealed hinge-end contacts. R&IE switches have weather-sealed contacts at the hinge end for continuous low-resistance current transfer. Exposed hinge-end contacts are vulnerable to ice locking and, when corroded, lower short circuit capacity. Look also for only nonferrous exposed live switch parts . . . an R&IE feature which assures long switch life.

3 Look for a sealed, greaseless switch bearing. This part transmits turning force from the operating crank to the switch actuating mechanism. The R&IE switch bearing, sealed against moisture and foreign matter, is not affected by low temperature and requires no lubrication. Unsealed bearings are subject to fouling by ice and dirt, making switch actuation difficult or impossible.

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Industrial Notes

(Continued from page 67A)

Radio Corporation of America New York, N. Y. . .

An intricate sound network provides a public address system, background music, and conference recording, as well as air-raid and fire warning, throughout the 22 floors occupied by the Socony Mobil Company in the firm's New York City skyscraper headquarters. The 42-story Socony Mobil Building is one of the first of its size with such extensive sound facilities, according to H. Emlein, manager, RCA Industrial and Audio Department, Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y. Commercial Radio and Sound Company, RCA sound products distributor, designed and installed the system, using RCA components throughout.

Joy Manufacturing Co. Burlington, Mass. . .

A newly established Boston branch office has been announced by the Industrial Division of Joy Manufacturing Company, producers of air compressors, dust collectors, fans, and conveyors. Formerly located at 88 Brookline Ave., Boston, Mass., the office is now functioning at Second Ave., Burlington, Mass. The new location was established to serve customers more efficiently throughout the New England states. The relocated Boston branch office also doubles as headquarters for the company's Mining and Construction Division serving the New England area.

General Instruments Corp. Newark, N. J. . .

To help the Armed Services ferret out secrets of the weather 15 to 25 miles above key ballistic missile launching sites, the United States Signal Corps has awarded to General Instrument Corporation, 65 Gouverneur St., Newark, N. J., an initial 1,500-unit production contract for a new "super-accurate" electronic weather detector which uses a liquid-filled miniature vacuum bottle to measure atmospheric pressure in the upper altitudes. Known as a hypsometer radiosonde, the new meteorological instrument, to be sent aloft by weather balloon, was developed by the U. S. Army Signal Engineering Laboratories, Fort Monmouth, N. J., and is being produced under Project Jupiter, for basic weather research connected with ballistic missiles programs. The hypsometer radiosondes also are to be used in the International Geophysical Year program. The new hypsometer is based on an ancient principle of measuring altitude by the boiling point of a liquid. This takes over from the bellows to measure atmospheric pressures at heights of 15 miles and up, where the fainter pressures make the bellows device inaccurate.

Completely Revised, October 1956 Issue

Electric Power Distribution for Industrial Plants

(RED BOOK)

No. 952

The purpose of this publication is to bring to the attention of engineers, owners, and plant management the important features of well-designed electric distribution systems that result in satisfactory performance of utilization equipment and efficient operation of the plant; it covers the features of the electric distribution systems which are applicable to most types and sizes of industrial plants. It sets forth the elements of the distribution system both as to what to do to accomplish desired results and the reasons for them. It does not explain in detail how to accomplish the final results.

Basic information is included to determine the approximate load requirements of industrial plants, the type of distribution system, the distribution voltages, and voltage regulation, as well as information to assist the engineer in the selection of transformers, circuit breakers, relays, meters, fuses, cables, bus, and miscellaneous equipment needed in the design of an adequate electric distribution system for present and future load conditions. Operating and maintenance problems are dealt with only in so far as they affect system and equipment selection. Basic information is included to determine load requirements, type of system, and voltages. Data are included to assist selecting transformers, circuit breakers, relays, meters, fuses, conductor, and miscellaneous equipment for present and future loads.

$3.50 per copy (50 per cent discount to AIEE members); 172 pages

---

Companion Publication (Also October 1956)

Grounding of Industrial Power Systems

No. 953

This publication covers the problems of system grounding, connecting the frames and enclosures of electric apparatus to a ground system, the problems of static, the methods of protecting structures against the effects of lightning, and the problems of obtaining a low resistance connection to the earth.

The popular name "Green Book" now applies to this new publication rather than to Interior Wiring Design for Commercial Buildings as before. The latter publication is out of print pending revision and when the new edition is available it will be known as the "Gray Book."

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Application of Incremental Heat Rates for Economic Dispatch of Power (July 1958)

This 52-page report summarizes the activities of the Working Group on Application of Incremental Heat Rates for Economic Dispatch of Power since it was organized in April 1956.

Included are six papers and a summary of round table discussions, valuable to the power industry, presented at the AIEE Fall General Meeting, October 10, 1957, in Chicago, Ill.

The price for publication S-104 is $3.00. Send to:

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Trade Literature

(Continued from page 68A)

Tantalum Capacitor Specification Chart . . .

An informative specification chart on Blu-Cap tantalum capacitors has been released by the **Fansteel Metallurgical Corporation, Rectifier-Capacitor Division, North Chicago, Ill.**

Electronic Communications Brochure . . .

This brochure describes the following Dualex Systems: the digital selective calling system, the Unitone system, the Pentone system, and the tapewriter and keyboard. **Bell & Gosset Company, 8234 Austin Ave., Morton Grove, Ill.**

Diode Information . . .

A pamphlet entitled "Rectifier News" and Bulletins *SR-201* (on industrial silicon power diodes) and *SR-163* (on rectifier subminiature diodes) are available from **International Rectifier Corporation, 1521 E. Grand Ave., El Segundo, Calif.**

Dual-Mode Excitation System Bulletin . . .

The Magaset dual-mode excitation system for a-c generator control is described in detail in Bulletin *8.010* now available. Covered fully, using circuit schematics, are principles of operation, actual performance results, specifications, and installation data. **Electric Regulator Corporation, Pearl St., Norwalk, Conn.**

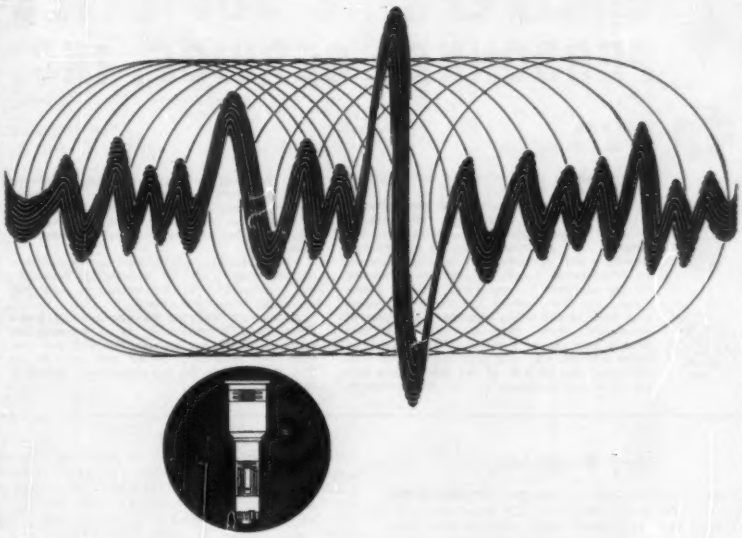
Electronic GO NO-GO Gauge Bulletin . . .

A 4-page bulletin describing a new electronic GO NO-GO gauge is now available. Series *620* instruments described in the bulletin are designed for frequency stability and comparison checks, motor speed control, pressure and flow control, material flow control, and other limiting situations occurring between 1 and 40,000 times-per second. For a free copy, address **Computer Measurements Corporation, 5528 Vineland Ave., North Hollywood, Calif.**

Contact Microradiography Booklet . . .

A 16-page booklet, giving technical facts on contact microradiography for research in biological, paper, textile, metallurgical, and foodstuff fields, is available gratis from the **Instruments Division, Philips Electronics, Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.**

(Continued on page 78A)



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Chief or Project Engr, B.S.E.E., 38. 15 yrs des, application and test of indicating and recording instruments, electro-mechanical devices and watthour meters. E-113.

Elec Des, M.S., 51. 8 yrs elec des of DC machines general and special (amplidynes, etc.) with outline of control (investigation of stability and transients) especially for large machine tools. 13 yrs elec design of DC traction machinery with outline of control. High level research and development work. E-114.

Field Engr, E.E., 53, registered Professional Engr; 30 yrs industrial and power house supervision of electrical construction. Will relocate. E-115.

Positions Available

Sales Manager for a manufacturer of electronic automation equipment, graduate mechanical engineer, with successful sales management experience in automated electronics production line equipment including conveyors, feeders, hoppers, machine controls, inspection equipment and gauges to the automotive and related industries; must be good supervisor and developer of sales personnel. Must know metal working problems and be familiar with tool room practices. Salary, to start, $15,000-$20,000 a year. Must be willing to travel nationally. Headquarters, Midwest. W-6552.

Director of Engineering for large California manufacturer of aircraft, missiles and electronic products. Must be college engineering graduate, Ph.D highly desirable. Must have outstanding technical reputation with ten to twenty years' experience in research and development and engineering activities. Compensation, $20,000-$25,000 a year with company car; $30,000-$40,000 paid life insurance and other generous benefits. W-6567.

Assistant to plant superintendent, graduate electrical, preferably with about two years' experience in engineering; to assist on various steam and electrical problems; eventually will assume supervision of all steam and electrical generation, both operating and maintenance. Excellent opportunity. Location, eastern Pennsylvania. W-6578.

Electrical Engineers. (a) Electrical Engineers, Senior, M.S. preferred, Intermediates and Juniors, B.S. degree, with from two to six years' experience in one or more of the following fields: (1) Theoretical and practical aspects of servo design; (2) Conception and design of radar pulse circuits; (3) Design of transistor circuits, both pulse circuits and linear amplifiers. Salaries, to $12,000 a year, depending on experience. (b) Senior Scientist, M.S. in electrical engineering or physics preferred, with four years' experience in microwave components, antennas; strong experimental experience; good theoretical background. Salary, to $12,000 a year. Must be U.S. Citizens. Location, New York, N. Y. W-6587.

Electronics Engineers (a) Electronic Engineers, magnetics design, B.S. in Physics but degree in electrical engineering will be considered; strong background in magnetics, design of pulse transformers, magnetic memory storage devices, etc. Will do product design of complex magnetic heads, small pulse transformers and related magnetic components. Some research and development assignments, with emphasis on product design. Salary, about $10,000 a year; fringe benefits. (b) Electronic Engineer, wave filter application and packaging, B.S. in E.E., plus knowledge of modern circuit analysis and synthesis, to design application-circuitry and electronic packaging for assemblies and subassemblies using ceramic band-pass filters and amplifiers. Must be basically a communication equipment circuit man with substantial transistor circuitry knowledge. Salary, to $10,000 a year. Location, Ohio. W-6589.

Products Sales Manager (Application Engineering), B.S. in E.E., with radio or electronic major; good knowledge of electro-mechanical filter applications; technical competence in field of wave filters of prime importance. Will deal directly with customers to provide application engineering to the customers' problems. Sales experience helpful. Salary, to $10,000 a year; generous fringe benefits. Location, Ohio. W-6590.

Engineers. (a) Electronic Engineer, System and Circuit Design, B.S.E.E., with heavy experience in system logic involving digital techniques of shift register, storage and highly stable timing circuits as applied to data conversion systems. Background in semi-conductor circuitry as applied to the above also required. Salary, $15,000 or more a year to start. (b) Associate Project Engineers, B.S.E.E., with one to three years' experience on electronic circuit design, transistor pulse circuitry. Design and testing of military equipment experience desirable. Salary, to $11,000 a year. Location, lower Connecticut. W-6592.

Quality Control Manager, graduate electrical or equivalent experience in insulated wire and cable field. Must be familiar with standard electrical testing equipment and related, government specifications and statistical quality control techniques. Will establish inspection procedures for new materials, work in-process and finished product. Salary to start, $7500-$8000 a year. Location, Connecticut. W-6604 (a).

Professor, Head, Department Electrical Engineering preferably with Ph.D or Masters degree, with minimum of five years' teaching experience. Knowledge of the scientific approach to servo-mechanisms, etc. desirable. Salary, $10,000-$12,000 a year. Location, South. W-6621.

Industrial Electronic Engineer, electrical graduate, with experience covering installation and operation of photo-cells, counters, detectors, recorders and TV including camera hook-ups. Must have good knowledge of photography. Salary, $7000-$8000 a year. Location Bergen County, New Jersey. W-6642.

Senior Electrical Engineer, graduate electrical, with a minimum of three years' electrical design experience consisting of rolling mills or fabricating plants. Will assist in carrying out electrical engineering projects involving design and alteration to new or existing equipment. Salary, $8580-$11,400 a year. Location, South. W-6647.

Market Research Engineer, B.S.M.E. or B.S.E.E., with a minimum of two years' sales engineering or marketing experience; technical product promotion experience. Experience in selling electronic, hydraulic or pneumatic instruments, automatic controls or test equipment high desirable. Will be responsible for gathering and analyzing data relative to existing and potential military and commercial markets. Salary, about $10,000-$12,000 a year, and profit sharing. Agency fees and relocation expenses will be negotiated. Location, New York State. W-6649.

Electrical Engineers. Senior positions open for development of special capacitors. Also project leader for DC to DC transformation circuits with nuclear batteries. Salaries open. Location, New York, N. Y. W-6663 (a).

Electrical Engineers, graduates, to work under chief electrical engineer in large pulp and paper mill. One to five years' experience in AC and DC rotating machines and control, sectional paper machine drives, mercury arc rectifiers and electronics control. Salary open. Location, North Carolina. W-6673.

Regional Sales Manager, graduate E.E., who has had demonstrated sales administrative ability and experience in the light industry. Should be willing to locate in the St. Louis area. Territory would cover Wisconsin, Michigan, Indiana and Ohio along with portions of Illinois, Kentucky and West Virginia. Salary, $12,000-$15,000 a year plus bonus. W-6680.

Product Engineer, M.E. or E.E. graduate, with twenty years' experience designing small electro-mechanical devices as end products. Should have proven background in application of engineering principles to product development. Company manufactures automotive accessories and household appliances. Salary, $12,000-$15,000 a year. Location, Connecticut. W-6694.

Engineers, B.S.M.E. or B.S.E.E., graduate degree desirable, with from one to three years' experience in product development, research or prototype production of small precision instruments or aircraft components. (a) Product Improvement Engineer to enter a product improvement group to run evaluation tests to determine deficiencies in product performance and devise and demonstrate improved designs and techniques. (b) Prototype Design Engineer to study and negotiate valve specification through sales with customer. Specify prototype valve design. (c) Production Engineer to assume responsibility for elimination of technical problems encountered in test and assembly of complex electro-hydraulic valves. Determine test equipment and procedure. (d) Reliability engineer to derive, conduct and report results of tests which determine degree of reliability of a product or sub-assembly design on the customary missile/aircraft environmental regimes. Should be experienced in environmental test circuitry and strong on instrumentation judgment. Salaries, to start $8000-$10,000 a year. Company will negotiate placement fees and relocation expenses. Location, upstate New York. W-6703.

(Continued on page 86A)

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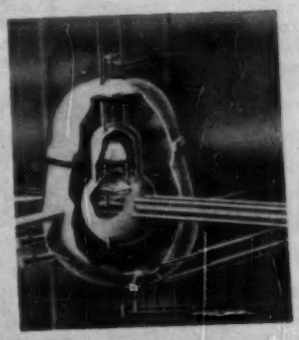

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- Radar transmitters and receivers
- Radar circuit design
- Antenna design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstron, traveling wave tube and backward wave oscillator
- Display and storage devices

CIVILIAN
POSITIONS OPEN

2-WAY RADIO COMMUNICATIONS
• VHF & UHF Receiver • Transmitter design & development • Power supply • Systems Engineering • Selective Signaling • Transistor Applications • Crystal Engineering • Sales Engineers

PORTABLE COMMUNICATIONS
• Design of VHF & UHF FM Communications in portable or subminiature development.

MICROWAVE FIELD ENGINEERS

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EQUAL JOB OPPORTUNITY For All Qualified Applicants

MOTOROLA

Trade Literature

(Continued from page 75A)

Underground Connector Catalog . . .

A catalog featuring the recently expanded and now complete line of Dossert underground connectors and fittings for use with underground distribution networks and industrial applications contains an unusual amount of technical information, specifications, and dimensional data. It is available from **Dossert Manufacturing Corp., 249 Huron St., Brooklyn, N. Y.**

Servo Calculator . . .

This plotting tool aid for the solution of network problems in servo analysis has been made available. Design engineers may obtain the Servo Calculator at no charge by writing on company letterhead to **Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.**

Relay Catalog . . .

This 20-page engineering catalog includes illustrations, specifications, and dimensional diagrams of the latest developments in microminiature rotary relays as well as extremely sensitive telephone-type relays of tremendous wear life which are available with a great range of contact combinations and long-time delay. **Magnecraft Electric Company, 33502 West Grand Ave., Chicago 51, Ill., Attention: H. D. Steinback.**

Sealants and Molding Compounds Data Chart . . .

A technical data chart describing polyurethane, Thiokol, and silicone-based electronic sealants and molding compounds which have excellent electrical properties, high temperature, and fuel and cold flow resistance may be obtained by contacting Coast Pro-Seal & Mfg. Co., 2235 Beverly Blvd., Los Angeles 57, Calif.

Digital Instruments Bulletin . . .

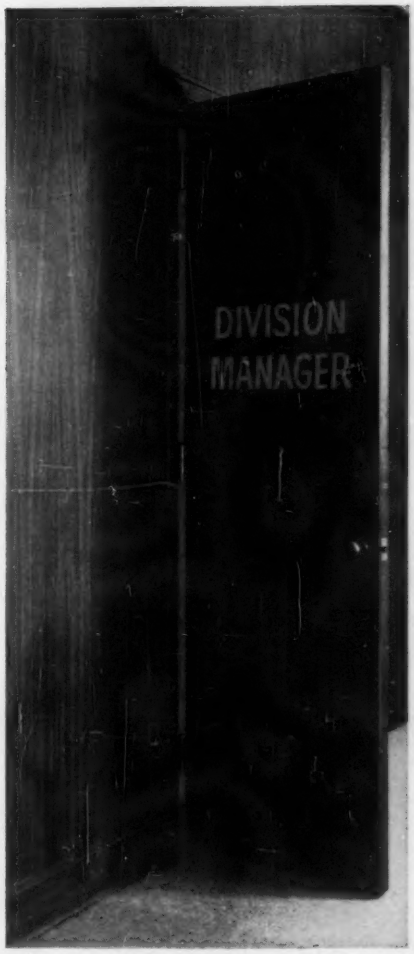
Principles and applications of servo null-balance digital indicating instruments are discussed in Bulletin No. *1758*, released by **Performance Measurements Co., 15301 W. McNichols, Detroit, Mich.**

Tubeaxial Fan Catalogue . . .

Performance and dimension specifications on the Series *300* tubeaxial fans are now available in a catalogue. This 7-page catalogue charts recommended stack sizes, maximum horsepower, and maximum motor speed (rpm) for variable stack velocity and air flow (cfm) output. For a copy of catalogue *1110-B*, write to **Westinghouse Electric Corporation, Sturtevant Division, Hyde Park, Boston 36, Mass.**

(Continued on page 82A)

How far can an engineer go at AC ?



Someday your name may go on the door of a top-management office of the AC Division . . . or of the General Motors Corporation. This is part of GM's "open door" policy. This means that not only is every GM door open to every employee, but that every open door represents opportunity. Today AC helps fulfill the large demand for inertial guidance systems (with the AChiever) and many other electro-mechanical, optical and infra-red devices. In the future AC will supply even more instrumentation needs —both military and commercial—for the "space era." Your long-range prospects at AC can hardly be equaled. You'll gain invaluable experience working shoulder to shoulder with recognized experts on many assignments. You'll enjoy highest professional status, which can be enhanced by working on advanced degrees at engineering schools located near AC facilities. You can work at AC facilities across the country or around the world. In short, if you are a graduate engineer in the electronic, electrical or mechanical fields, *you can go places at AC, because AC is going places.* This is worth looking into. Just write the Director of Scientific and Professional Employment: Mr. Robert Allen, Oak Creek Plant, Dept. B, Box 746, South Milwaukee, Wisconsin; or Mr. M. Levett, Dept. B, 1300 N. Dort Highway, Flint 2, Michigan. It may be the most important letter of your life.

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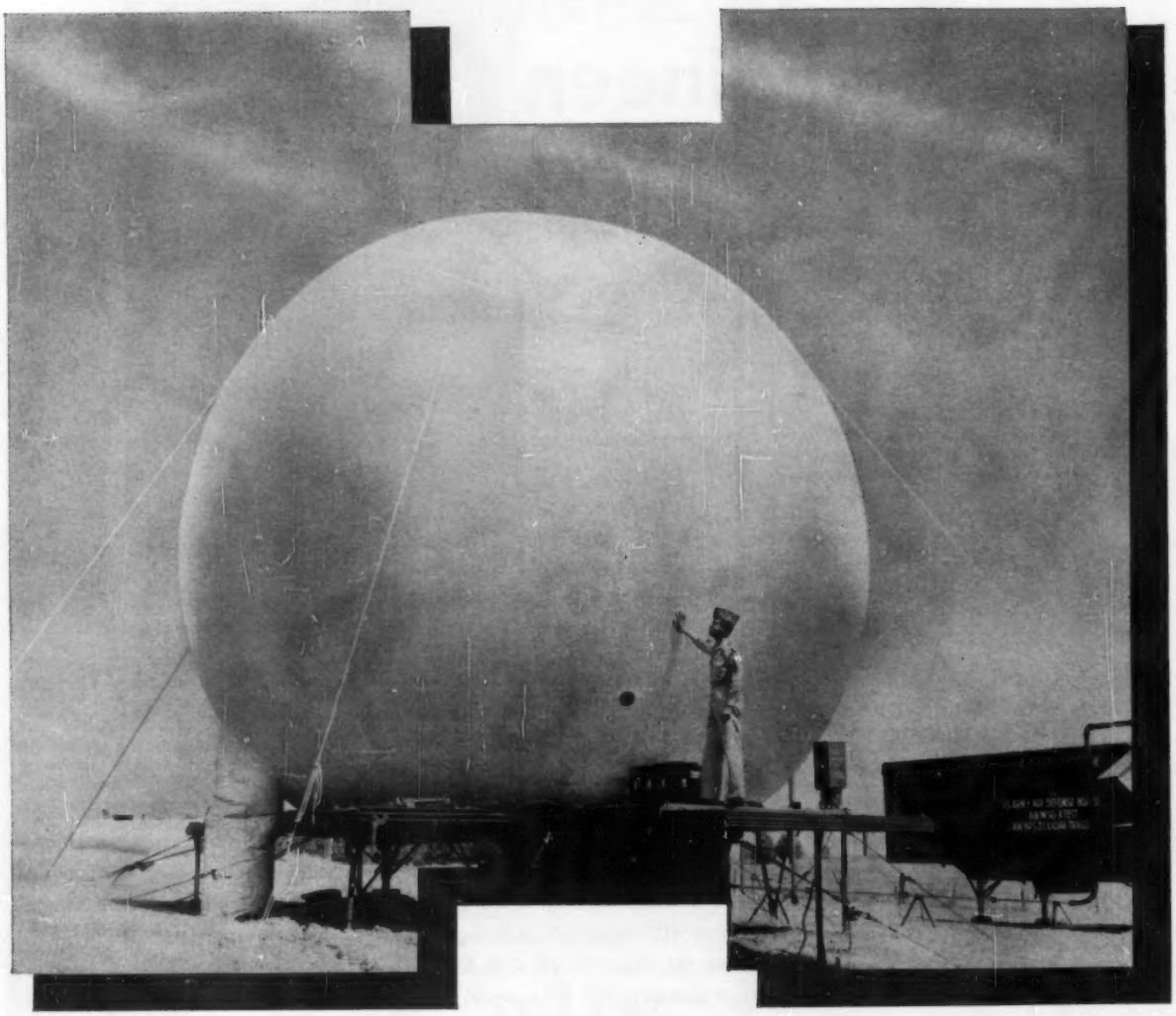
AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

The strange shape



# of defense

This plastic balloon, resting on a mobile trailer bed like a golf ball on a tee, protects the new Hughes three-dimensional radar antenna.

Frescanar, the exclusive system combining high-speed data processors and a frequency scan radar antenna, has been developed by Hughes engineers in Fullerton, California.

Sensitive to the inadequacies of conventional radar, these Hughes Fullerton engineers have devised a radar antenna whose pointing direction is made sensitive to the frequency of the electromagnetic energy applied to the antenna. This frequency sensitivity results in the radar beam being radiated from the antenna at different angles, depending on the frequency of the energy supplied. With the supply of a succession of frequencies, the antenna beam can be moved through a succession of positions. Utilizing this advanced technique, range, bearing and altitude can be detected . . . on a single antenna.

This Hughes-developed radar system has been combined with compact, high-speed Hughes data processors to provide a completely self-sufficient, mobile radar defense system.

Other Hughes projects provide similarly stimulating outlets for creative engineering talents. Current areas of Research and Development include Advanced Airborne Electronics Systems, Space Vehicles, Nuclear Electronics, Subsurface Electronics, Ballistic Missiles . . . and many more. Hughes Products, the commercial activity of Hughes, has assignments for imaginative engineers for research in semiconductor materials and microwave tubes.

The diversity and advanced nature of Hughes projects provides an ideal environment for the engineer or physicist interested in advancing his professional status.

An immediate need now exists for engineers in the following areas:

Microwave & Storage Tubes	Reliability Engineering
Field Engineering	Systems Analysis
Quality Control	Circuit Design
Semiconductors	Communications
Digital Computer Engineering	Radar

Write in confidence, to Mr. Phil N. Scheid,
Hughes General Offices, Bldg. 6-D-2, Culver City, California.

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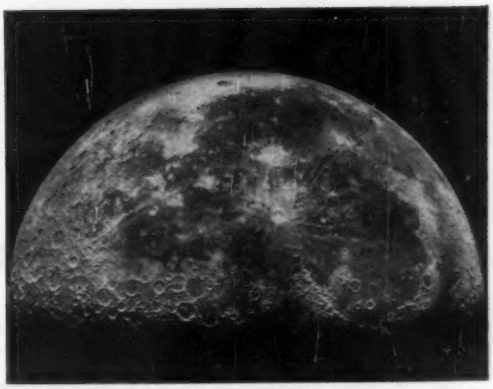
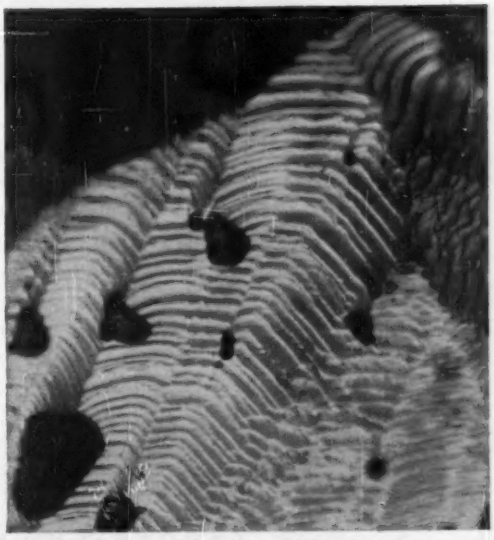


The Hughes Communications Laboratories have as one objective the development of systems capable of deflecting their signals from meteors, artificial satellites and even the moon.



This photomicrograph of an etched silicon sphere is used in basic studies of semiconductor materials at Hughes Products, the commercial activity of Hughes.

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This is one of a series of professionally informative messages on RCA Moorestown and the Ballistic Missile Early Warning System.

BMEWS AND THE SYSTEMS ENGINEER

Military science, in its need for large-scale, complex automatic equipment, has provided the environment for the evolution of the modern systems engineering concept. To meet the challenge of defense electronics particularly, this comprehensive and logical approach to engineering has steadily grown into a discipline in its own right.

BMEWS, a military electronics system of immense proportions, requiring the cooperative development efforts of four major corporations operating under RCA leadership, vigorously demonstrates the role of systems engineering in modern technology. Conceived by the Department of Defense and RCA systems engineers in 1955, BMEWS is evolving from mathematical model to hardware maturity entirely within the framework of the systems concept. The systems engineer is using his special tools of information theory, computing, probability, operations research, linear programming and other techniques to resolve the complex challenges of early detection of enemy ICBMs.

As an architect of defense, the RCA Moorestown systems engineer is also giving close scrutiny to the equipment requirements of the space vehicle age and to the physics of the generation of weapons beyond.

Engineering scientists who are interested in joining the Systems Engineering activity at RCA Moorestown are invited to address inquiries to Mr. W. J. Henry, Box V-9M.

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MISSILE AND SURFACE RADAR DEPARTMENT

MOORESTOWN, N. J.

Trade Literature

(Continued from page 78A)

A-c and d-c Crane Control Bulletins . . .

Two bulletins on a-c and d-c crane control have been published. Both bulletins describe master switches, disconnects, limit switches, frequency relays, brakes, and other components of various crane control systems. For copies of Bulletins *6100* (d-c crane control) and *6400* (a-c crane control) write to **Electric Controller and Mfg. Company, Division of Square D Company, 4500 Lee Rd., Cleveland 28, Ohio.**

Physical Properties of Organic Chemical Fluids . . .

Physical properties of nine organic chemical fluids which are said to exhibit outstanding resistance to radiation and thermal damage are described in literature published recently. The nine fluids, five of which are available in commercial quantities, are polyphenyl compounds and certain of their alkyl derivatives. The booklet, which details the physical properties of selected representatives of the alkyl derivatives, can be obtained by writing to M. McEwen, **Monsanto Chemical Company, Lindbergh and Olive Street Rd., St. Louis 24, Mo.**

Strain Gauge Pressure Transducers Bulletin . . .

Publication of a technical brochure on gauge, absolute, and differential pressure measurements is announced. Entitled "Glennite Strain Gauge Pressure Transducers," the brochure describes the performance, application, mechanical and electrical specifications, compatibility in installations, and instructions for ordering the instruments. Also included are circuit diagrams, a typical installation, and a basic explanation of the operation of the equipment. Direct requests for Bulletin Series *PSG-1* to the Sales Manager, **Gulton Instrumentation Division, Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.**

Fork Truck Time-Study Bulletins . . .

Thirty seconds daily suffices to put a battery on charge, the only daily maintenance job most users of electric industrial battery-driven fork trucks will probably ever have, is stated in one of the new bulletins offered by Exide Industrial Division, The Electric Storage Battery Company. Step-by-step photos and instructions in the two bulletins show the recommended sequence for carrying out each of these operations, and how easily they are performed in the stopwatch times cited. For a copy of Bulletins *5996* and *6207*, write **Exide Industrial Division, The Electric Storage Battery Company, P. O. Box 8109, Philadelphia, Pa.**

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Challenging opportunity in small electronic development laboratory dealing with problems involving special purpose photographic production machinery and equipment.

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Mr. Edwin J. Bloom, Jr., Employment Dept., ANSCO, Binghamton, N.Y.

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An experienced engineer is required for work in our systems development group. He should possess an above average electronics background and from two to six years of experience in servomechanisms, infra-red, and missile guidance development. Advanced degree, preferable, but will consider outstanding personnel with a B.S. degree.

This is a challenging opportunity for qualified personnel to fully utilize their creative ability on highly diversified research assignments while enjoying stimulating staff associations and receiving an excellent salary and liberal employee benefits. Professional development is encouraged through publication of papers, participation in professional activities and our education program providing for tuition free graduate study.

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When answering an advertisement, send all replies to box number specified, c/o ELECTRICAL ENGINEERING, 6th Floor, 33 West 39th Street, New York 18, N. Y., unless other address is given.

Positions Open

ELECTRICAL ENGINEER — Electrical Engineer interested in electrical design of power plants or industrial plants. Experience not required. Excellent opportunity with consulting engineering firm in Middle West. Liberal benefit plans and good working conditions. Send resume of education and experience with statement of salary requirements to: Box 492.

GENERAL ELECTRIC ADVANCED ELECTRONICS CENTER at Cornell University has openings for experienced electronic engineers and physicists. As the Advanced Engineering Component of the Light Military Electronic Equipment Department, the Center is responsible for Applied Research and Advanced Development of Airborne Electronic Equipment. Current work at the Center includes Electronic Warfare, Radar, Communications, Data Processing, Weapons Systems Engineering, Proximity Fuses, Magnetic Amplifiers, Human Engineering, Infrared and Transistors. Replies stating education, experience and salary requirements should be addressed to Dr. Paul Doigan, General Electric Company, Advanced Electronics Center at Cornell University, Ithaca, New York. All replies will be kept confidential.

ASSOCIATE OR PROFESSOR OF ELECTRICAL ENGINEERING to teach undergraduate courses in communications and part time research. To twelve thousand for eleven months. Ph.D. degree. Dean of Engineering, University of Santa Clara, Santa Clara, California.

ELECTRICAL ENGINEERING DEPARTMENT HEAD — Excellent opportunity available for young teacher with Ph.D. Should have teaching and industrial experience. College located in San Francisco Bay Area, electronics industry research, development and manufacturing center. Academic rank and salary open. Write to N. O. Gunderson, Head, Division of Engineering, San Jose State College, San Jose 14, California.

TEACHERS NEEDED for permanent staff in an expanding department. Salaries depending on experience and academic background. Write to Electrical Engineering Department, Louisiana State University, Baton Rouge, Louisiana.

ASSISTANT OR ASSOCIATE PROFESSOR OF ELECTRICAL ENGINEERING to teach undergraduate courses in communications or servomechanisms. Opportunity for part time research. MS or Ph.D. degree. Salary dependent upon qualifications. Location, Virginia. Box 702.

DESIGN ENGINEER—Experienced in circuit breaker design and development. Multi-plant, nationwide electro-mechanical corporation. Newark, New Jersey area. All benefits. Include box number in resume. Address Box 703.

TEACHING POSITIONS. Assistant, Associate or Full Professor of Electrical Engineering, M.S. or Ph.D. required. Nine month salary range presently $5000-$9000. Full year appointments available. Salaries are increasing rapidly. Candidate should be well-prepared to teach in new undergraduate program with strong engineering science emphasis and in EE graduate (MS) program. Apply to A. T. Murphy; Head, Department of EE; University of Wichita; Wichita 14, Kansas.

TRANSFORMER ENGINEER. One who is thoroughly familiar with designing and supervising building of dry as well as oil sealed power distribution transformers. There is a good chance for advancement for the right man. Location New Jersey. State experience, salary, etc. Box 704.

ELECTRICAL ENGINEER GRADUATE—For design of small integral AC motors, Must have some previous experience in electrical motor design. Locate in Mid-West. Box 705.

ELECTRICAL ENGINEERING TEACHING POSITION. Excellent opportunity is available for a properly qualified person in a new, expanding department. Location is in the Midwest at a medium size university. Rank and salary commensurate with qualifications. Appointment is available beginning February or September. Send complete resume to Box 706.

ASSOCIATE PROFESSOR OF ELECTRICAL ENGINEERING. To teach and supervise research in Division of Engineering Research and Development effective September, 1959. Ten month basis Ph.D. required or essentially completed. Write Head, Department of Electrical Engineering, University of Rhode Island, Kingston, Rhode Island.

ENGINEERS—College positions. All sections U.S., all fields of engineering. Openings for B.S., M.S., and Ph.D's. Excellent salaries. Send pictures and qualifications to Cline Teachers Agency, Box 607, East Lansing, Mich.

CHIEF ENGINEER. 44000KW Steam Generating Plant now under construction, Sea Coast, Southern Peru, the applicant must be capable of taking responsibility for Operation and Maintenance. Should have five to ten or more years central station experience. For details as to salary, living conditions, contact Mr. John L. Splane, 410 Arizona Land Title Building, Tucson 1, Arizona.

SCIENCE AND ENGINEERING AT ROBERT COLLEGE OF ISTANBUL. Opportunities at Robert College in Istanbul, Turkey, for qualified men in engineering, mathematics, physics and chemistry interested in combining teaching and consulting with the opportunity to live and travel in a vital part of the world. Development program is in effect to strengthen staff, modernize undergraduate curricula, inaugurate graduate program, construct new science and engineering building, prepare engineers for the industrial and technological development of Turkey and the Middle East. A challenging work with far-reaching possibilities. Address inquiries to Dr. Duncan S. Ballantine, President, or Dean Howard P. Hall of the College of Engineering at Robert College, Bebek P. K. 8, Istanbul, Turkey, with copy to the Near East College Association, 40 Worth St., New York 13, N. Y.

ELECTRICAL DESIGN ENGINEER, graduate E.E., with experience in the design of transformers, (pulse transformers and line type modulators) and pulse forming networks. Should have practical knowledge of drafting practices and procedures; general knowledge of production practices and equipment; methods engineering; production planning, etc. Will be responsible for design of above listed products. Salary to $10,000, plus company sponsored benefits. Company also pays moving and travel costs. Location, central Pennsylvania. Box 707.

PROFESSORS, PH.D., Fields and computers especially. Large graduate Program. Income $9,000-$12,000 with research. Box 708.

INSTRUCTORS AND RESEARCH ENGINEERS to work for D.Sc. at University of New Mexico. Large Graduate program assures variety of available courses. Chairman, E. E. Dept., University of New Mexico, Albuquerque, N. M.

Positions Wanted

ELECTRICAL ENGINEER—University Graduate, two year test course and three years experience in Switchgear and Protective Relay Application with Manufacturing Company. Age 28, married. Box 709.

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Publications Available from the AIEE

The following publications are sponsored jointly by the American Institute of Electrical Engineers and the other societies mentioned below.

1. **PROCEEDINGS OF THE EASTERN JOINT COMPUTER CONFERENCE** (Computers in Business and Industrial Systems), Nov. 7-9, 1955, Boston, Mass.

   Sponsors: The Association for Computing Machinery, AIEE, The Institute of Radio Engineers.

   100 pages, 15 papers and discussions. Price: $3.00.

2. **PROCEEDINGS OF THE EASTERN JOINT COMPUTER CONFERENCE** (Computers with Deadlines to Meet), Dec. 9-13, 1957, Washington, D.C.

   Sponsors: The Institute of Radio Engineers, The Association for Computing Machinery, AIEE

   259 pages, 48 papers and discussions. Price: $3.00.

3. **PROCEEDINGS OF THE WESTERN JOINT COMPUTER CONFERENCE,** Feb. 26-28, 1957, Los Angeles, Calif.

   Sponsors: The Institute of Radio Engineers, AIEE, The Association for Computing Machinery

   240 pages, 37 papers and discussions. Price: $4.00.

4. **PROCEEDINGS 1957 ELECTRONICS COMPONENTS SYMPOSIUM,** May 1-3, 1957, Chicago, Ill.

   Sponsors: AIEE, The Institute of Radio Engineers, Radio-Electronics-Television Manufacturers Association, West Coast Electronic Manufacturers Association; also Agencies of the U. S. Department of Defense, and the National Bureau of Standards

   282 pages, 43 papers. Price: $5.00.

5. **1958 NATIONAL TELEMETERING CONFERENCE,** June 2-4, 1958, Baltimore, Md.

   Sponsors: Institute of Aeronautical Sciences, AIEE, Instrument Society of America, American Rocket Society

   317 pages, 63 papers and abstracts. Price: $4.00.

6. **NONLINEAR MAGNETICS & MAGNETIC AMPLIFIERS PROCEEDINGS,** Aug. 6-8, 1958, Los Angeles, Calif.

   Sponsors: AIEE, The Institute of Radio Engineers, The Instrument Society of America

   482 pages, 30 papers. Price: $7.00.

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Proceedings of the Computers in Control Systems Conference (May 1958)

THE PAPERS PRESENTED at this conference held October 16-18, 1957 in Atlantic City, N. J., by scientists from the United States, and representatives of the USSR, France, and England, were intended to spotlight the present development in the use of computers in the design process, and as elements of feedback control systems.

It is felt that this international interchange of information will be mutually advantageous to visitors to the conference from abroad, as well as to those from the United States.

The 189-page publication of 31 papers was sponsored by the Feedback Control Systems Committee, AIEE, the Professional Group on Automatic Computers, Institute of Radio Engineers, and the Instruments and Regulators Division, American Society of Mechanical Engineers. Price of publication *T101* is $3.50. Send to:

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(Continued from page 76A)

Electrical Engineers. (a) Senior Engineer, B.S.E.E., with five to ten years' circuit design experience; three years' minimum on electronic communications equipment or allied fields such as computer. Salary, $12,000-$14,000 a year. (b) Junior Test Engineer, graduate electrical, with two years' minimum experience testing military electronic equipment. Write test procedures, supervise test department. Salary, $6000-$8000 a year. Location, Connecticut. W-6707.

Electrical Engineer, M.S.E.E. but B.S.E.E. with extensive experience is acceptable. Heavy training in mathematical analysis of electrical circuits required. Will have direct technical supervision over all electrical design and production release work. Experience should include three to five years' minimum of design and development work on electromechanical devices typical of office equipment devices. Extensive experience in report preparation. Salary, $8000-$12,000 a year. Company pays placement fee. Location, Connecticut. W-6706 (b).

Technical Assistant to Service Manager, electrical graduate or electrical technical school graduate, with three to eight years' experience in factory level service engineering, recruitment, training and administrative management in customer service for office equipment or related industry. Some travel. Salary, $5500-$7000 a year. Location, Connecticut. W-6704.

Electrical Engineers. (a) Graduate electrical, for work in cost operations, depreciation, mortality data and statistics. (b) Graduate electrical, from well known technical school, with several years' experience, with a telephone company in traffic engineering. Salaries open. Location, South. W-6712.

Design, Development Engineer, Computer Electronics, major or Masters', at least three years' recent experience with electronic and electro-mechanical elements of computor equipment (circuitry, transistorizing, relays, vacuum tubes.) Able to draw layouts and take care of development work for manufacturing company. Employer will discuss payment of placement fee and relocation costs. Salary, up to $10,000 a year. Location, San Francisco East Bay. S-3818.

Senior Application Engineer, electrical equipment, B.S.E.E., with five or more years' in electrical power industry involving applications of large circuit breakers, switchgear, transformers, substations. Must be able to direct group in sales department preparing proposals and price estimates based upon engineering studies and analyses of customers needs and assist field representatives in getting orders. Salary, $8000-$10,000 a year. Location, California. S-3891.

Project Design Engineer, Electronic Power, for design, development, test, installation and maintenance of equipment for extensive radar detecting systems. (a) Electrical Project Engineer, $10,000-$16,000 a year; Design, $7000-$15,000 a year; Installation, $7000-$13,000 a year. (b) Mechanical: Design, $7000-$15,000 a year; Installation, $7000-$13,000 a year. U.S. Citizens. Placement fee and interview expenses paid by employer. Locations, New Jersey and North. S-3902.

Research and Design Senior Engineers, electronics, E.E., minimum of five years' experience in electronic circuitry, transistors, specifications and product related to digital transducer type equipment. No boardwork, responsible for development of prototype for approval, test and manufacture. Salary, $8400 a year. Location, San Francisco East Bay. S-3916.

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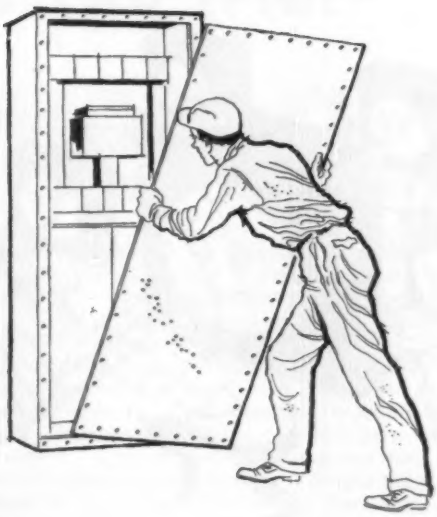

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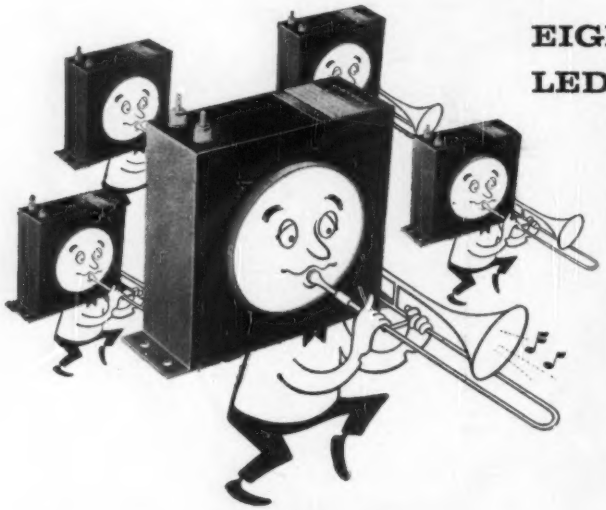

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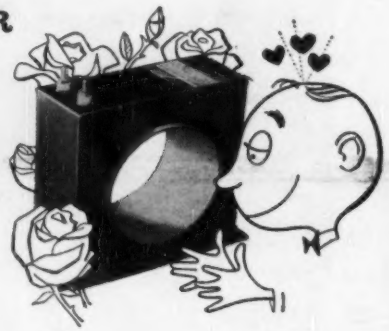

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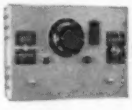

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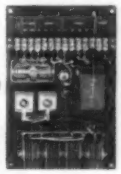

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a new concept in tuning reliability

You are looking at the first published picture of the tuned-coupled cavities of an RCA Tunable Magnetron. In development for several years, this unit is setting a new standard of reliable magnetron performance—because it provides an effective tuning system *outside the high electrical field region of the anode.* Here are a few of the advantages: RCA's coupled-cavity tuning (1) does away with tuner arcing, and galling, or jamming—(2) provides a rugged mechanical tuning system thus minimizing vibration-induced frequency modulation—(3) offers improved mode stability at high rates of rise of voltage pulse—(4) permits uniform power output across the tuning range of the magnetron—(5) lends itself to "customized" tube designs for virtually any magnetron frequency and power requirement.

Designed for superior performance throughout long life, RCA New-Concept Tunable Magnetrons are now offered in a wide choice of designs for either hand- or servo-drive tuning. And note this: *They have been thoroughly proved for operating reliability and long life in microwave systems under the most adverse conditions of military field environment.*

For information on RCA Tunable Magnetrons—and how RCA's Coupled-Cavity tuning concept can help solve your problems involving the application of tuned magnetrons—call the RCA Field Office nearest you.

GOVERNMENT SALES

415 South Fifth St., Harrison, N. J. • HUmboldt 5-3900
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INDUSTRIAL PRODUCTS SALES

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RAymond 3-8361

What You "Need To Know"

Oscillating frequency is determined by the electrical dimensions of mechanically actuated tuning lines (external to tube anode). Cavities store RF energy through electrical coupling to the anode—resulting in vastly improved mode stability. Unlike other tuning methods, new RCA Coupled-Cavity tuning assures optimum mechanical and electrical tube performance—because tuner and anode structures can be designed independently!

RCA Tunable Magnetrons For Pulsed Oscillator Service

Type No.	Frequency Range (Mc)	Tuning System	Peak Power Output (kw)	Duty Cycle	RRV kv/-μsec.
7008	8500-9600	Servo-tunable	230	0.001	225
7110	8500-9600	hand-tunable	220	0.001	225
7112	8500-9600	remote-tunable	220	0.001	200
7111	8500-9600	hand-tunable	220	0.001	200
A-1127	8500-9600	hand-tunable	280	0.001	200
6865-A	8750-9600	hand-tunable	220	0.001	180
A-1086-G	8750-9600	hand-tunable	240	0.001	160

A Milestone — RCA's 2,000,000,000 Tube Year

RADIO CORPORATION OF AMERICA
Electron Tube Division **Harrison, N. J.**

New RCA Microwave Tube folder (1CE-180). A handy listing of RCA Magnetron and Traveling-Wave Tubes and their salient characteristics. Free—from RCA Commercial Engineering, Section L-16-Q, Harrison, N. J.